Practical Sheet Metal Work and Demonstrated Patterns

John Henry Teschmacher

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PRACTICAL

SHEET METAL WORK

AND

DEMONSTRATED PATTERNS

A COMPREHENSIVE TREATISE IN SEVERAL VOLUMES ON

SHOP AND OUTSIDE PRACTICE AND PATTERN DRAFTING

VOLUME X

HEAVY IRON AND PIPE WORK

COMPILED FROM THE

METAL WORKER

PLUMBER AND STEAM FITTER

EDITED BY

J. HENRY TESCHMACHER, JR.

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PREFACE

IN this volume X of the series PRACTICAL SHEET METAL WORK AND DEMONSTRATED PATTERNS, there are presented many examples of pattern cutting, in which due thought has been given in the exemplification to the fact that the problems deal with articles made from extra heavy material and require a procedure which makes allowance for such stock. There are also many articles included which describe practical methods of handling heavy metals and making finished products therefrom. The feature of this book, which it is deemed will make it exceptionally valuable, is the many problems presented to demonstrate the method of obtaining the patterns, likewise the making of pipes of various contours in cases that require the full science of projection and developing of surfaces of solids, all of which comprise pattern cutting.

The files of METAL WORKER contain a fund of information invaluable to those engaged in the sheet metal trade, by reason of having command of the services of experts in the fields of endeavor it represents. Through the generosity of that journal, this information was made available for these series so that it might be obtainable in book form, duly sorted so far as possible, into volumes on subjects of like category, and with an aim not to intrude in the province of the THE NEW METAL WORKER PATTERN BOOK. Many of the articles chosen were printed by METAL WORKER without the names of the authors being appended; and it can only be stated that George W. Kittredge and William Neubecker were the principal contributors. To all, however, the publishers express sincere thanks.

J. HENRY TESCHMACHER, JR.

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CONTENTS

	PAGE
Patterns of Intersection between Elbow and Scalene Cone	1
Patterns of Elbow with Double Offset	5
Patterns for Three-pieced Transition Elbow having an Offset	8
Pattern for Locomotive Cab Rain Shield	11
Bending Heavy Plate Steel to Arc of a Circle	13
Making and Erecting a Smokestack	13
Facilities for Working Wrought Iron	19
Pattern for Side of Boiler Breeching	21
Pattern for a Pipe Branch with its two parts joined	22
Ascertaining Miter Lines of Elbows in Discharge Piping of Conveyor System	24
A Boiler Flue Connecting Problem	28
Pattern for a Tapering Elbow	32
Method of Supporting Sheet Metal Flues	34
Heavy Metal Patterns for Pieced Elbows	35
Pattern for a Y Oblong to Round	38
Adjustable Sleeves for Steam Pipes	40
Patterns for Elbows Mitering with Round Pipe	41
Obviating Noises in Fan Systems	45
Constructing a Rectangular Duct	48
Galvanized Iron Work for Fan Systems	49
Estimating the Weights of Rectangular and Round Piping and Specifications	59
Finding True Angles in Blower Connection	63
Punching Sheet Iron	64
Lining Elevator Bins with Heavy Sheet Iron	66
Gravel Roofer's Kettle and Fire Place	72
Points on Working Heavy Sheet Iron	74
Patterns for Irregular Pieced Elbows	79
Patterns for a Forge Hood	84
Pattern for Sheet Iron Forge Hood	86
Pattern for Three-way Branch	88
Patterns for Tapering Fork	92
Reducing Offset in Pipe Work	93
Rectangular and Oval Pipe Fork	95
Finding the True Angle in a Flaring Object	99
Some Short Rules for Developing Patterns	100
Patterns for a Pipe to Describe a Helical Curve about a Cylinder	103
Pattern for Twisted Transition Elbow	107
Pattern for Compound Curved Tapering Elbow	111
Pattern for a Room Air Diffuser	113
Patterns for a Branch Intersecting Scalene Cone and Transition Piece	115
Another Method for a Pattern for Three-way Branch	119
Patterns for Intersecting Pipes	121
Tapering Elbow in Square Pipe	124
Patterns for Intersecting Tapering Elbows	126
Patterns for Ship Ventilating Cowl	130
Patterns for an Irregular T Joint	134

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Practical Sheet Metal Work and Demonstrated Patterns

PATTERNS OF INTERSECTION BETWEEN ELBOW AND SCALENE CONE

In Fig. 1 is shown a piece of pipe work, the patterns for which are here developed. This illustration shows two 20-inch elbows connected to two boilers. The elbow A connects to a 20-inch smoke pipe. By means of a transition or scalene cone B the smoke pipe is enlarged to 28 inches in diameter. Into this scalene cone B elbow C connects. For the pattern for the intersection between the elbow and the pipe A, see "Pattern for Elbow Mitering with Round Pipe" on page 41 of this book.

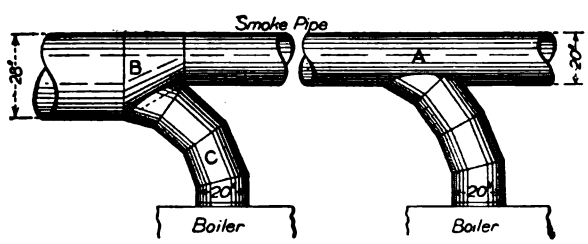

Fig. 1. Sketch of the Problem

For the pattern for the elbow joining the scalene cone B, proceed as is shown in Fig. 2, in which first draw the elevation of the pieced elbow, as is shown by A B C D, and the profile M. Draw the scalene cone W V J S and the cylinder T W V U as shown. As only one section of the elbow H I J K miters with the cone, the problem merely consists of the intersection of a cylinder with a scalene cone. Should, however, two sections of the elbow miter with the cone, which would occur if the elbow had more pieces, the same principles as those which would follow would be employed.

Directly below the side elevation draw the plan. Extend J V in elevation until it intersects S T to T. Then will T be the apex of the scalene cone shown in plan by X. Divide the half plan A^1 C^1 X into an equal number of spaces, as shown by the small figures 6 to 12. From these draw lines to the apex X. The elbow will not cut any deeper into the cone than between 7 and 8 in plan, therefore at right angles to X A^1, and from points 7 and 8, erect lines intersecting S J in elevation at 7 and 8. From these draw lines to T.

Now divide the profile M into an equal number of parts by the small figures, from which at right angles to A B draw lines intersecting the miter line G F at

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2, 3 and 4. Parallel to G H and from these points draw lines intersecting the miter line H I. Then again parallel to H K draw lines crossing the miter line K J and the radial lines T 6, T 7 and T 8 of the cone, as shown.

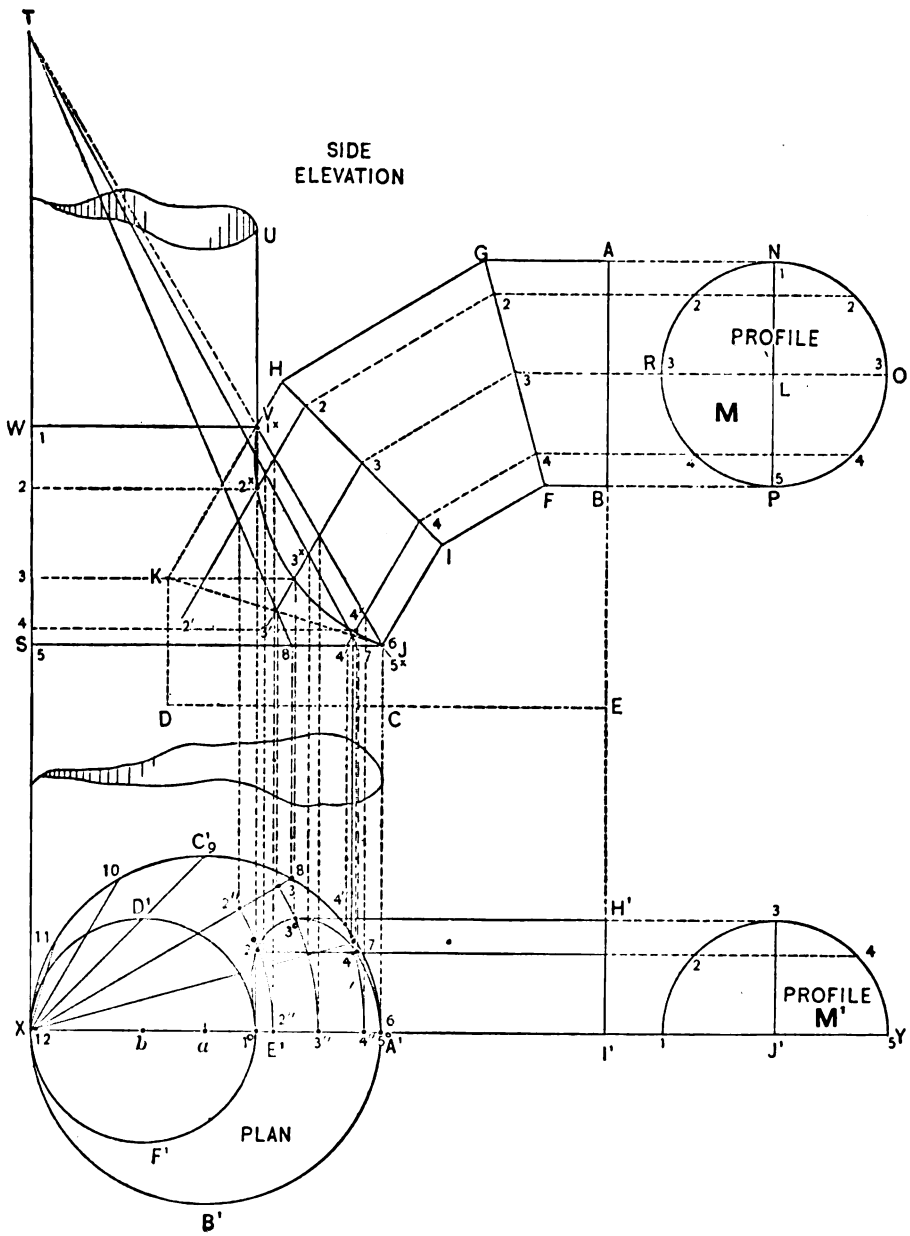

Fig. 2.
Determining the Intersection Lines

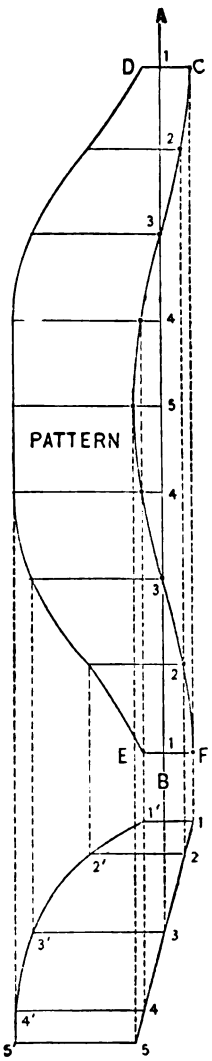

Fig. 3.
Developing the Pattern

The next step is to obtain horizontal sections through the scalene cone on the lines 2 2′, 3 3′ and 4 4′, for which proceed as follows: From the intersections, where the line 2 2′ of the elbow crosses the radial lines T 6, T 7 and T 8 of the

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cone, drop lines parallel to W S, intersecting X 6, X 7, X 8, which are similar radial lines in plan. Trace a line through the points thus obtained shown by 2″ 2″, which will represent the half horizontal section on 2 2′ in elevation. In similar manner obtain the section line 3″ 3″ in plan, representing the horizontal section on 3 3′ in elevation: 4″ 4″ represents the horizontal section on 4 4′.

As the center line of the elbow comes directly in the center of the cone, as shown in plan, one half plan is all that is necessary in practice. Extend the center line of the cone X A^1 as shown by X Y upon which place the half profile of M shown by M^1. Divide M^1 into the same number of spaces as contained in one half of M. As 1 and 5 in elevation represent the top and bottom of the elbow respectively, the figures 1 and 5 are placed in the position shown in plan in M^1 and still represent the top and bottom. As the 1 and 5 in M intersect the cone at top and bottom respectively, then must the points 1 and 5 in plan intersect the top and bottom respectively of the cone in plan, as shown by 1° and 5°.

As the points 2, 3 and 4 of the profile M intersect the section lines in elevation 2 2′, 3 3′ and 4 4′ respectively, then must the lines drawn from the points 2, 3 and 4 in the profile M^1 in plan parallel to X Y, intersect the section lines 2″ 2″, 3″ 3″ and 4″ 4″, respectively at points 2°, 3° and 4°. Trace a line through intersections thus obtained, as shown by 1° 2° 3° 4° and 5°, which will represent the line of joint in plan between the elbow and the cone. For the miter line, or line of joint in elevation, draw lines at right angles to X Y in plan, from the intersections 1° to 5° intersecting similar numbered lines in the elbow in elevation as shown by points of intersections, 1^x, 2^x, 3^x, 4^x and 5^x. Through these points draw the miter line V J.

The patterns for the two upper sections of the elbow are drawn in the usual manner. For that of the lower section take a tracing of H I J V and place it in Fig. 3 as shown by 1 1^1 5^1 5. Draw the stretchout line A B and obtain the pattern C D E F in the usual manner. For the pattern for the scalene cone proceed as follows: Take a tracing of J S W V and place it as shown by J S W V in Fig. 4. Also take a tracing of the half plan in Fig. 2 and place it as shown by similar figures in Fig. 4, reversing it, as shown. Parallel to J S in Fig. 2 and from the intersections 1^x to 5^x draw lines intersecting the vertical line W S at 1, 2, 3, 4 and 5. Take these various hights on W S and place them on W S in Fig. 4, as shown. Extend S W and J V until they intersect at T, which is the apex in elevation; 12 represents the apex in plan. Then using 12 as center draw arcs intersecting 12 6 in plan, as shown. From these points at right angles to 12 6 draw lines intersecting S J at 6′, 7′, 8′, 9′, 10′, 11′ and 12′. Draw lines to the apex T.

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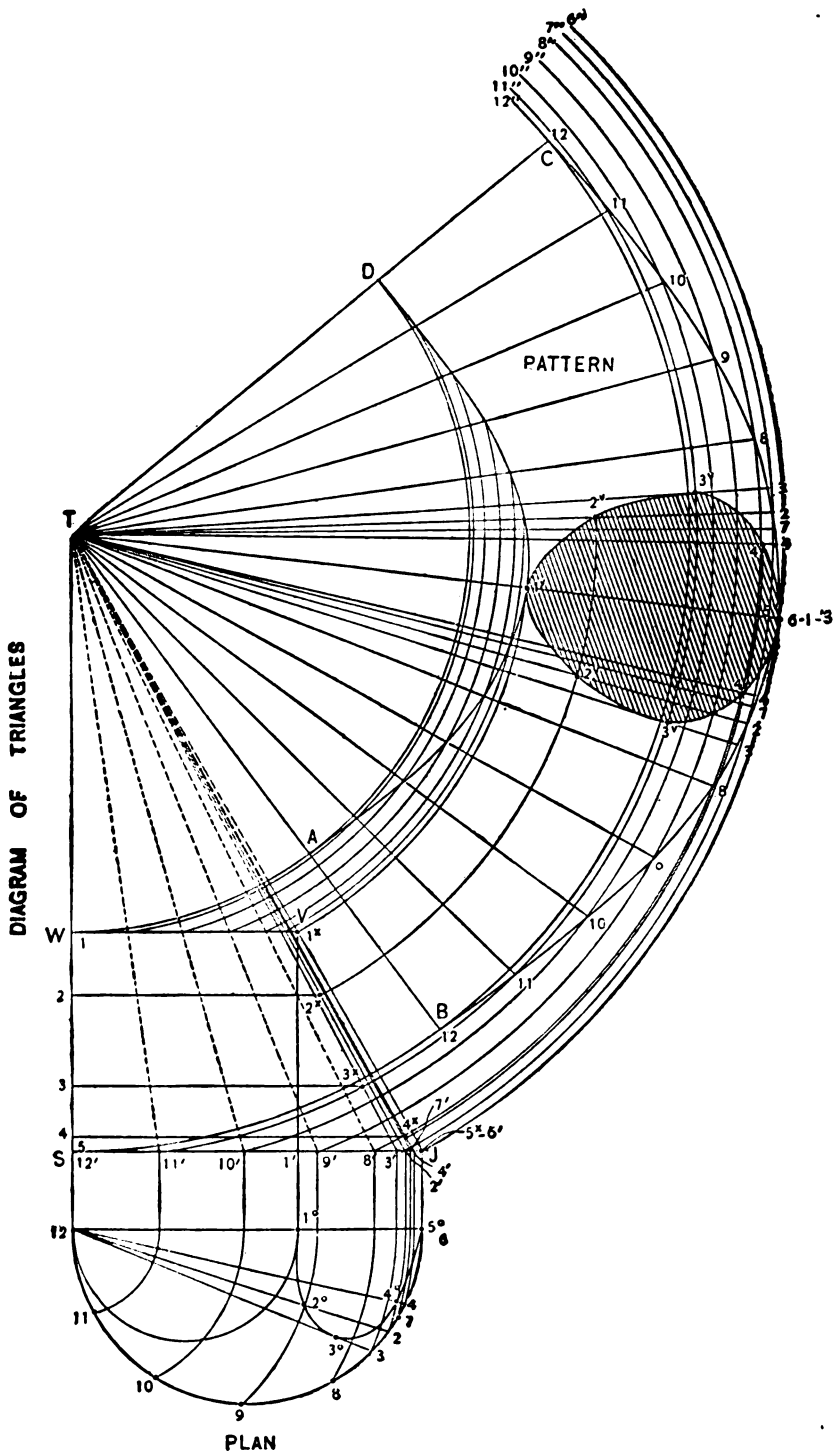

Fig. 4. Developing Pattern and Opening of Scalene Part

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Next using the apex T as a center draw the arcs 6′ 6″, 7′ 7″, 8′ 8″, 9′ 9″, 10′ 10″, 11′ 11″ and 12′ 12″, as shown. Set the dividers equal to one of the spaces into which the half plan is divided, and starting from 12 on the arc 12′ 12″, step from one arc to another, having similar numbers, thus obtaining the points 12 to 6 to 12, through which draw the curve shown. From 12, 11, 10, 9, 8, 7, 6, 7, 8, 9, 10, 11 and 12, draw lines to the center T. Using T as a center, and radii equal to the various intersections on W V draw arcs, intersecting similarly numbered radial lines in the pattern, as shown, through which draw the curved line A D. Then will A B C D be the pattern for the scalene cone.

For the opening to be cut in the cone proceed as follows: Through the intersections 2°, 3° and 4° in the plan in the miter line, draw lines to the apex 12, extending them until they intersect the semicircle at 2, 3 and 4 respectively. Then using 12 as a center, describe arcs intersecting the center line 12 6 as shown. At right angles to 12 6, and from these intersections draw lines intersecting S J at 2′, 3′ and 4′. From these points draw lines to T. It will be noticed that the points 1° and 5° in plan intersect the line W V at 1^x, and the line S J at 5^x, respectively.

At right angles to S T and from the intersections 2, 3 and 4 on W S, draw lines intersecting the radial lines T 2′, T 3′ and T 4′, as shown at 2^x, 3^x and 4^x. Take the distance from 7 to 4 in plan and place it on the curved line B C in pattern, as shown from 7 to 4 on both sides. In similar manner take the distances from 7 to 2 and 8 to 3 in plan, and place them on the curved line B C of the pattern, as shown from 7 to 2 and 8 to 3 respectively on both sides. From the points 3, 2, 4 and 4, 2, 3 on the curved line B C, draw lines to the apex T, which intersect with arcs drawn from 2^x, 3^x and 4^x, using T as center, thus obtaining the intersections in the pattern 2^y, 3^y, 4^y, on either side. Trace a line through points thus obtained as shown by the shaded portion, which will be the required opening.

PATTERNS FOR ELBOW WITH DOUBLE OFFSET

To obtain patterns for a double elbow, as shown in elevation in Fig. 5, the vertical hight of which is eqal to *a b* and the offset equal to *c d*, the profiles of the pipes being oblong with semicircular ends, proceed as follows:

In work of this kind it is not necessary to draw the foreshortened elevation shown by *e a*. All that is required is the plan view, from which an oblique

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elevation is drawn, as shown in Fig. 6, in which C represents the profile of the upper elbow and D a similar profile for the lower elbow, the offset between the two being equal to the distance B. Connect the two profiles by the lines E and F, which completes the plan view, from which the oblique elevation of the elbow is drawn at right angles to the plan line E as shown by the pieces I to V, the vertical hight of the elbow being equal to the distance A. Care should be taken in drawing the oblique elevation of the elbow to have all angles and miter lines alike, so that the pattern cut for one piece will answer for all five. Now through the centers *a* and *b* of the semicircular ends in the profile D draw lines at right angles to the flat sides of the profile D, as shown by 6, 10 and 1, 5. Then divide the semicircular ends into equal parts as shown by the small figures 1 to 10.. At right angles to the plan lines E or F, from the small figures 1 to 10 in D erect lines until they intersect the first miter line as shown by similar numbers. Extend the line X H in elevation as shown by J K, upon which place the stretchout of the profile D as shown by similar numbers 1 to 10 to 1. Through these small figures at right angles to J K draw lines indefinitely as shown, which intersect by lines drawn parallel to J K from similar numbered intersections on the miter line in elevation. Trace a line through points thus obtained, then will 1 L M 1 be the pattern for piece I, also the miter cut for all the other pieces.

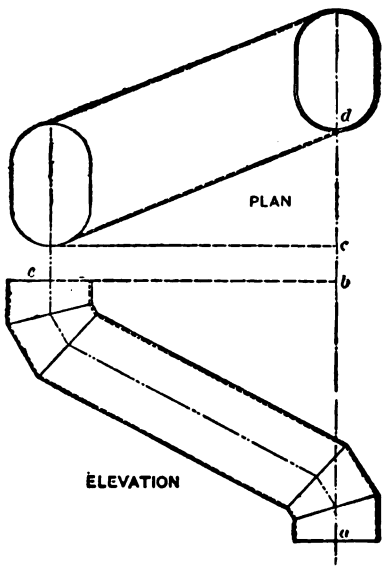

Fig. 5. Sketch Submitted

To obtain the balance of the patterns from one piece of metal without waste, proceed as follows: As the outline of the elbow in elevation is in line with points 2 and 7 in the profile D, then upon lines drawn from 2 and 7 in the pattern must the measurements be placed. Therefore at right angles to J K from points 2 and 7 draw lines indefinitely as shown. Now take the distance from 7 to 7′ in elevation and place it on line 2 in the pattern as shown by *i j*. In a similar manner take the distance from 2 to 2′ in elevation and place it on line 7 from *c* to *d*. Next take a tracing of the miter cut L *i c* M, reverse it so that the points *i* and *c* will come upon *j* and *d*, and obtain the miter cut O *j d* N. Then will L M N O be the pattern for piece II.

Take the distance in elevation of either 7′ 7″ or 2′ 2″, as they are both alike, because the miter lines run parallel to each other, and place it as shown from

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j to *k* and *d* to *e* in the pattern, and trace the miter cut O *j d* N, having *j d* come on *k e* without reversing the cut, and obtain the miter cut P R. Then will N O P R be the pattern for piece III.

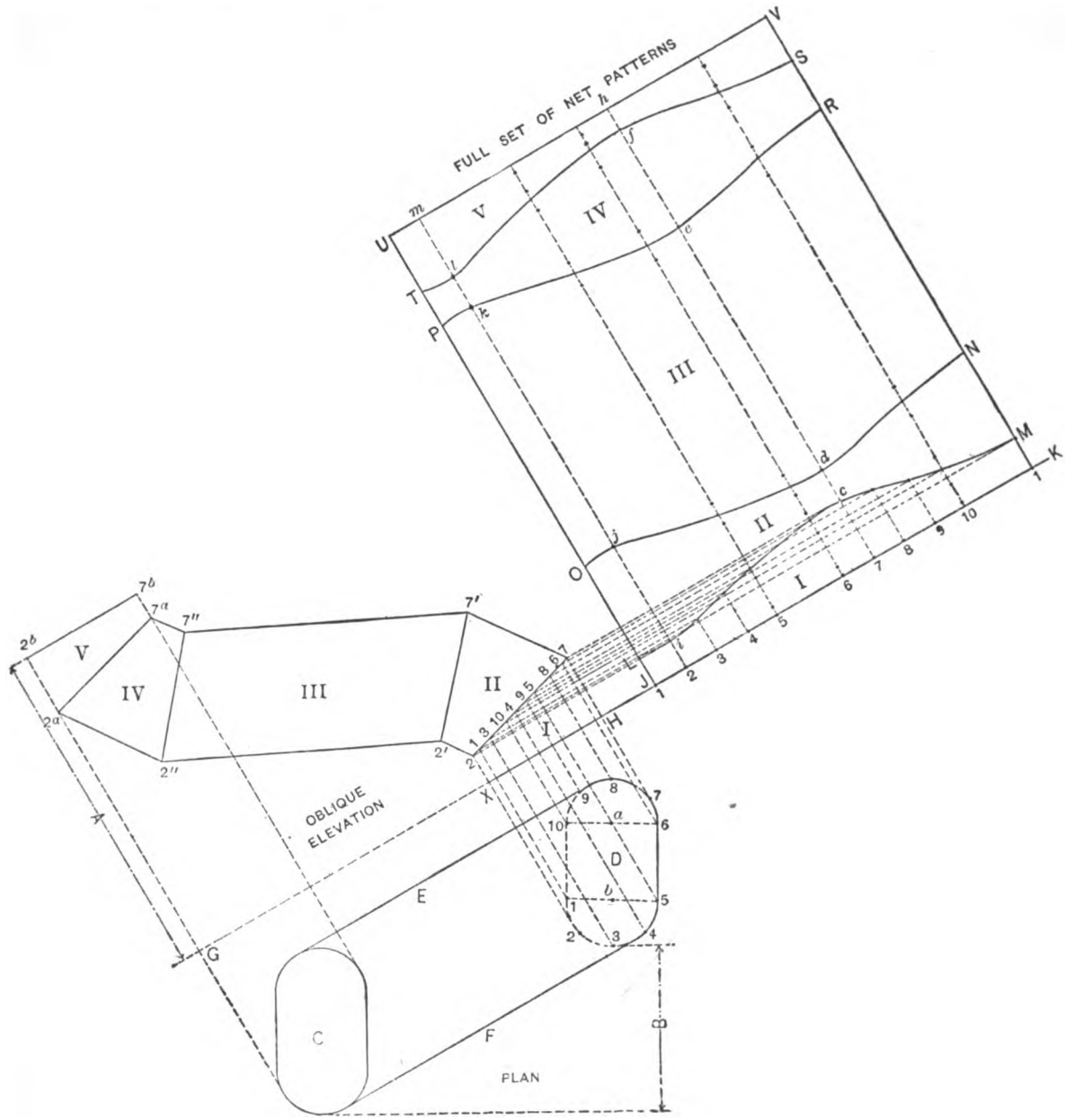

Fig. 6. Details of Pattern for Double Elbow With Offset

Next take the distances from 2″ to 2ª and from 7″ to 7ª in elevation and place them as shown in the pattern, from *e* to *f* and *k* to *l* respectively, and trace the miter cut P *k e* R, reversing it so that *k* and *e* will come over *l* and *f* and obtain the cut T S. Then will P R S T be the pattern for piece IV.

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Finally take the distances from 2^a to 2^b and 7^a to 7^b in elevation and place them in the pattern as shown respectively from *l* to *m* and *f* to *h* and draw a line through these two points *m* and *h* until it is intersected by lines erected from points 1 and 1 in the pattern. Then S T U V is the pattern for piece V.

It should be noted that these patterns are net—that is no allowance has been made along the miter cuts for seaming or riveting. In practice the amount of this edge must be added to the various pieces parallel to the miter cut.

PATTERNS FOR THREE-PIECED TRANSITION ELBOW HAVING AN OFFSET

For the pattern of a round to an oval three-pieced elbow with regular 45 degree backset, the transition to be in the middle section and oval section to be offset, proceed as follows:

In Fig. 7 are shown several of the conditions laid down. The length of the oval profile X is equal to the diameter of the round profile Y. The first step is to draw a proper side elevation of the elbow as follows: On a horizontal line, A C, set off the distance of the throat A B and the diameter of the round pipe B C. From A erect the perpendicular line A E equal to A C, and using A as a center draw the quadrants B D and C E. From B and C erect perpendicular lines and from D and E draw horizontal lines. Intersect these by the two lines drawn tangent to the quarter circles at *a* and *b* at angles of 45 degrees. Draw the miter lines 6 1 and 5′ 1′ and this completes the side elevation of the elbow.

In line with E D draw the profile X of the oval pipe, and in line with B C the profile of the round pipe Y. Divide both semicircles in both the oval profile X and round profile Y into similar number of parts as shown. From the various divisions 1 to 10 in the profile X draw lines at right angles to E D, or parallel to E 6, until they cut the miter line 6 1 from 1 to 10. Extend the line D E as H J, upon which place the girth of one half the profile X as shown by the small figures 1 to 6 on H J. From these small figures at right angles to J H draw lines which intersect by lines drawn parallel to H J from similar numbered intersections on the miter line 1 6. Trace a line through intersections thus obtained; then will 6 6″ 1″ 1 be the half pattern for the oval pipe, with seams at 1 and 6 in profile X. If the full pattern is desired with seam at 1, then reverse K on the line 6 6.″

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From the various intersections in Y erect vertical lines at right angles to B C until they cut the miter line 1′ 5′ as shown. To obtain the pattern for the round pipe erect any vertical line, as B^1 C^1, and place the girth of one half the profile Y as shown by the small figures on B^1 C^1. Through these small figures at right

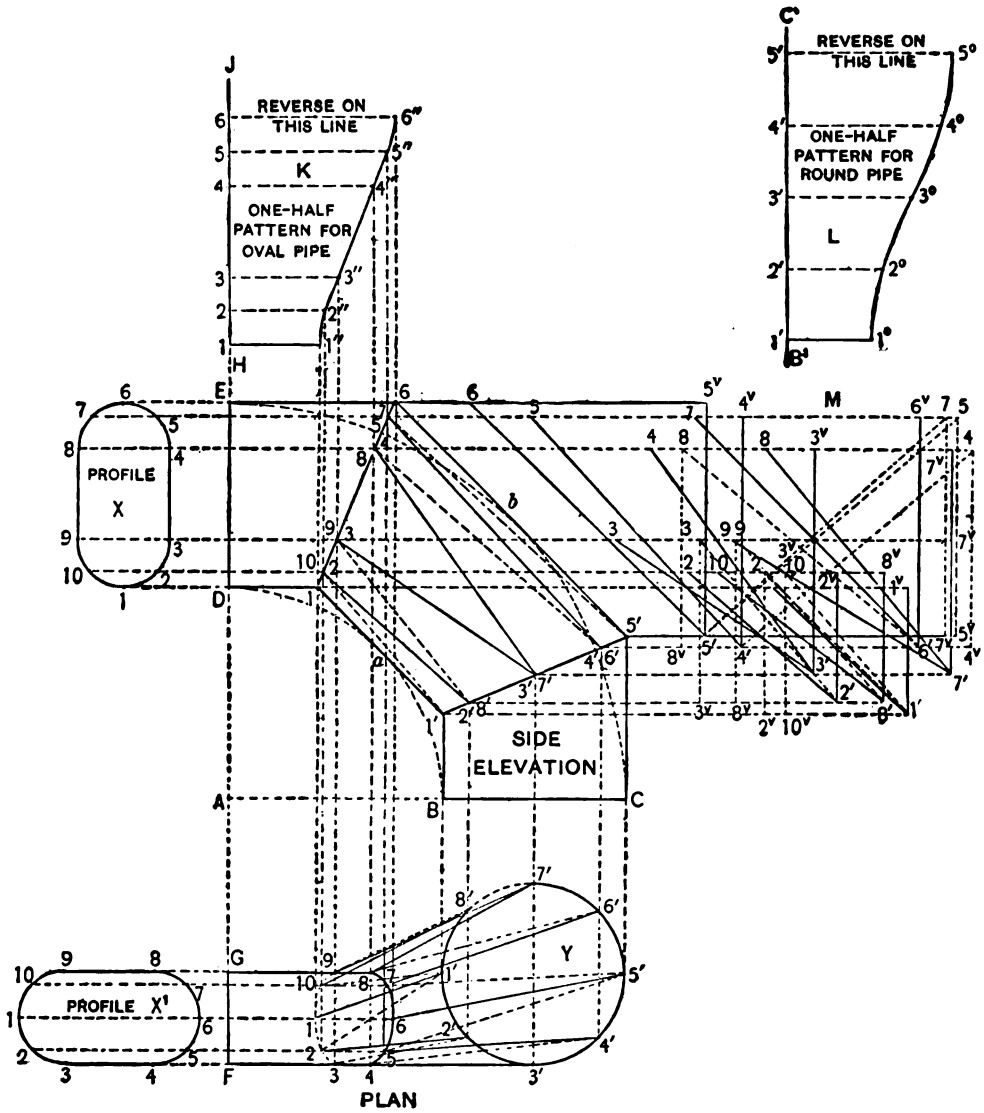

Fig. 7. Diagram of Triangles Showing True Lengths of Solid and Dotted Lines in Plan

angles to B^1 C^1 draw lines indefinitely as shown. Measuring from the line B C in the side elevation take the various projections to points 1′ to 5′ and place them on corresponding lines in L, measuring in each instance from the line B^1 C^1. A line traced through points will be the half pattern for the round pipe with seams at 1′ and 5′ in plan. If the full pattern is desired with a seam at 1′ in Y, then reverse the pattern L opposite the line 5′ 5°.

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To obtain the pattern for the middle transition piece a correct plan view must first be drawn showing the horizontal section through the miter line 6 1 in elevation. From the point 3′ in the profile Y draw the tangent line 3′ F, which is intersected at F by a perpendicular line dropped from D in the side elevation. Take a tracing of the profile X and place it in the position shown by X^1 spacing it in the same size divisions as in X. Through the various intersections in X^1 draw horizontal lines, which intersect by vertical lines drawn from similar numbered intersections on the miter line 6 1 in elevation, thus obtaining points 1 to 10 in plan. A line traced through these intersections will represent the view looking down of the miter line 6 1 in elevation. Connect by solid lines 1 in the miter line to 1′ in the profile Y; 2 with 2′; 3 with 3′; 4 with 3′; 5 with 4′; 6 with 5′; 7 with 6′; 8 with 7′; 9 with 7′, and 10 with 8′. Draw dotted lines from 1′ to 2; 2′ to 3, and others as shown. Connect solid and dotted lines in elevation to correspond as shown.

From the various intersections on the miter lines 6 1 and 5′ 1′ in elevation, draw horizontal lines to the right indefinitely as shown, and proceed to construct the true lengths as follows: For example, to find the true length of the solid line 1 1′ in plan, take this distance and set it off on the horizontal line drawn from 1 on the miter line 6 1 in elevation as shown from 1 to 1ᵛ; from 1ᵛ draw the perpendicular line until it intersects the horizontal line drawn from 1′ on the miter line 1′ 5′ in elevation at 1′. Draw a line from 1 to 1′ in M, which will be the true length of 1 1′ in plan, or elevation. To find the true length of the dotted line 5 5′ in plan, set off this distance on the horizontal line drawn from 5′ in elevation, as shown from 5′ to 5ᵛ, and from 5ᵛ erect the vertical line until it intersects the horizontal line drawn from 5 in elevation at 5. Draw the dotted slant line 5 5′ in M, which is the true length of 5 5′ in plan or elevation. In this manner are all the true lengths of the solid and dotted lines found.

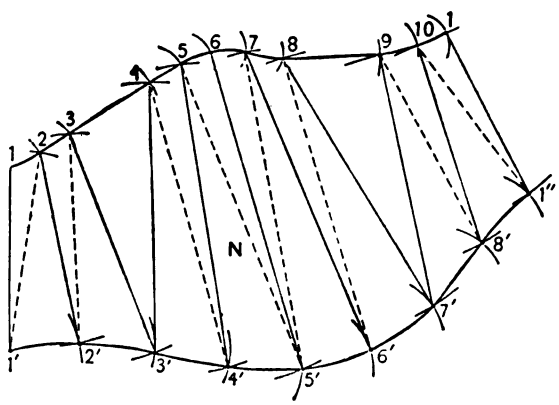

Fig. 8. Pattern for Transition Piece

In laying out the pattern for the transition piece no sections will be necessary on the miter lines 6 1 and 1′ 5′ in elevation, as the true distances along the miter lines will be taken from the miter cuts in diagrams K and L. The transition piece is developed as follows: Assuming that the seam is to come on 1 1′, in plan or elevation, then take the

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true length of 1 1′ in M and place it as shown in N, Fig. 8. Now with 1″ 2″ in K as radius, and 1 in N as center, describe the arc 2, which intersect by an arc struck from 1′ as center and the true length of the dotted line 1′ 2 in M as radius. With 1° 2° in L as radius and 1′ in N as center, describe the arc 2′, which intersect by an arc struck from 2 as center and the true length of the solid line 2 2′ in M as radius. Proceed in this manner using alternately first the divisions in the miter cut in K, then the true lengths of the dotted slant lines in M; the divisions in the miter cut in L, then the true lengths of the solid slant lines in M, until the line 6 5′ in N has been obtained. Then using similar divisions in K and L (as the opposite halves of these patterns are similar) proceed to complete the pattern N to 1 1′. Trace a line through points thus obtained; then will 1 6 1 1″ 5′ 1′ be the full pattern for the transition piece.

PATTERN FOR LOCOMOTIVE CAB RAIN SHIELD

To lay out a pattern for a rain water shield to lie on top of the back end of a locomotive cab, its object being to protect the fireman while coaling the boiler, as shown by Fig. 9, it is suggested that if the locomotive is already built, a template be made of a combination of light sheet iron and strips of wood. This template must fit over the roof of the cab, thereby obtaining its outline. From this template the half end elevation of the cab can be drawn on paper. The shape of the upper edge of the shield may be drawn as fancy dictates.

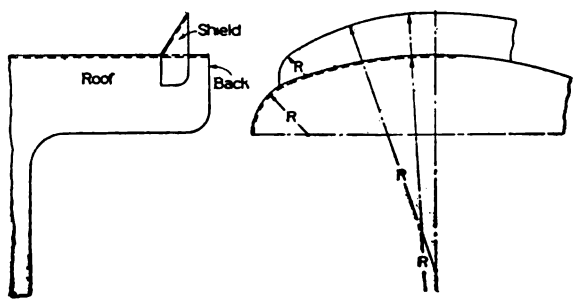

Fig. 9. Sketch Showing Locomotive Cab Rain Shield

For large drawings the sketching of a profile is, of course, accomplished most readily by the use of white chalk. After acquiring an outline that pleases, it can be drawn in with the lead pencil and the chalk brushed off. Of course, if the outline of the cab is to be ascertained from a scale drawing, it can be drawn by means of a trammel to the radii stipulated by the scale drawing; and it is not likely that these radii will be of a length to preclude trammels.

Having the end and side elevation as shown in Fig. 10, for the pattern, divide the outlines of the cab and shield into equal parts—the shield from point V 6. From V 6 to Z 6 divide again into equal spaces. Connect 1 to 1 and W, X and Y to Z 6. Also connect O R to 1, etc., with dotted lines.

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The true lengths of the hypotenuses of the system of triangles, of which these lines are the bases, are learned by drawing a horizontal line and erecting a perpendicular line to it, on which is placed the altitude of the triangles (constant in all) or the distance A B of side elevation. From B in the diagram of triangles, shown at the top of Fig. 10, and to the left, place the spaces in end elevation of Z 6 to Y, X, W and V 6, also 5 to 5, etc. And to the right the spaces O R to 1, etc.

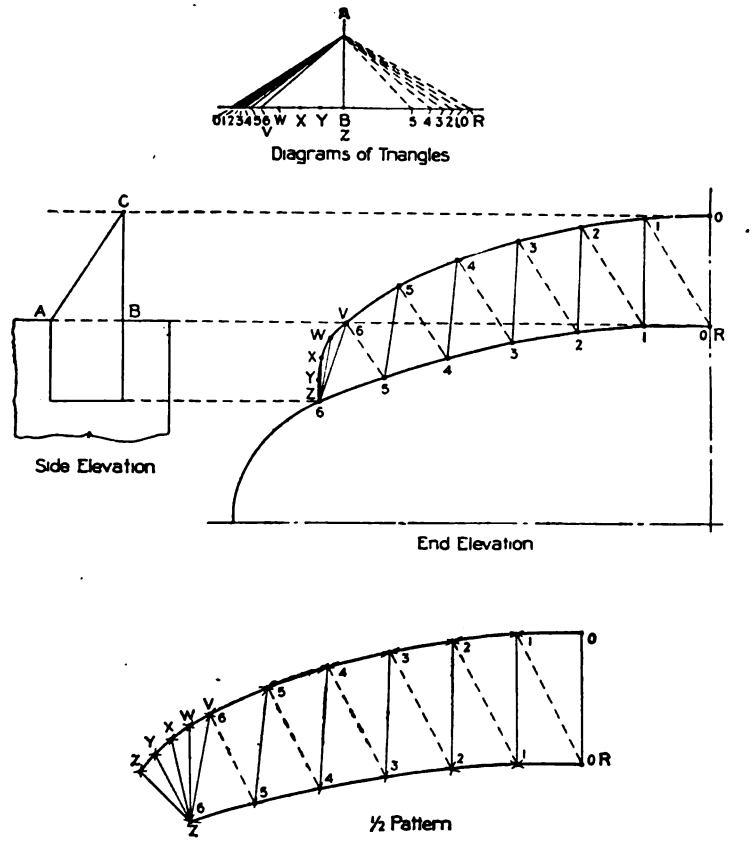

Fig. 10. Method of Obtaining Pattern for Rain Shield

The pattern is laid out by drawing any line of a length equal to 0 A of the diagram of triangles or A C of the side elevation; this line is indicated by 0 0 R of the half pattern. With the compasses set to 0 R A (0 R 1) of the diagram of dotted triangles, strike an arc, using the end of the line 0 R of the pattern for a center. This arc is intersected by one struck from 0 as a center and of a length coinciding with 0 1 of the outline of the shield. From this point of intersection, 1, as a center, strike an arc equal to 1 A of the diagram of solid triangles, which is intersected by an arc from 0 R equal to 0 R 1 of the outline of the cab roof, all as shown.

Continue in this fashion until V 6, Z 6 is obtained, then from Z 6 as a center strike arcs of the length of Z 6, W, Z 6, X, etc., of the diagram. With the dividers set to the space, in the end elevation, Z Y, etc., step off, beginning at V 6, this space on these arcs. A line traced through these points will give one half of the pattern.

In all probability this shield will be made of heavy iron, and therefore the thickness of the metal should be allowed for, proportionally, in the spaces, and a riveting edge along 0 R Z 6 and Z to Z 6.

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BENDING HEAVY PLATE STEEL TO ARC OF A CIRCLE

In Fig. 11 the points A and B are the edges showing the flat parts usually present when heavy plates are passed through rollers of large size, if the edges are not first turned to the sweep of the circle desired by using a heavy wooden maul for the purpose. It is almost impossible to make a perfect curve by this method, even if done by skillful workmen. A method by which to accomplish the result desired, without the use of a maul or other treatment of the plate before it is formed in the rollers, is as follows: Place the steel plate to be rolled between two plates of a heavier gauge in the manner shown in Fig. 12. The three plates are shown in the position they bear to each other during the process of forming. The heavier plates must be of the length of the plate that is to be formed and of sufficient width to project beyond the side edges of it a distance somewhat greater than from the points A and B of the plate shown in Fig. 11 to the edges. When rolling the plates, the outside or heavier plates only will be flattened at the start and finish, while the center or lighter plate will form up perfect to the sweep to which the rolls are set.

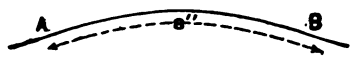

Fig. 11. Showing Curve With Flat Ends

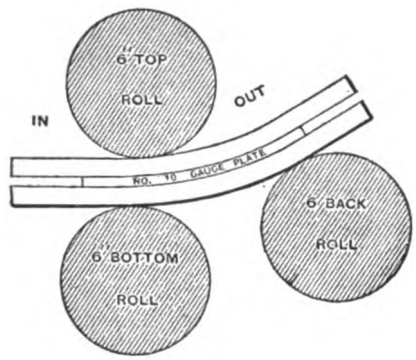

Fig. 12. Manner of Rolling the Plate to Circular Shape

MAKING AND ERECTING A SMOKESTACK

The subject of this article is an ordinary smokestack, and every operation necessary for its production and erection will be set forth in consecutive order exactly as it would be executed for a job of this kind.

As the metal man is seldom called upon to determine the size of such a stack the ratio of area and hight of flue to grate area, etc., will be passed over and it will be assumed that a 16-inch black iron stack, with oblong base 10 × 26 inches, is wanted, using No. 16 30 × 120-inch stock, and that it fits on a cast iron collar on top of the smoke box, extends through the boiler house roof, and is secured in a vertical position by three guy rods.

The first thing necessary is a sketch drawn to about ¾-inch scale, showing an elevation and plan of the stack, as in Figs. 13 and 14, upon which to mark the dimensions, etc., for ready reference and to show at a glance just what is to be done.

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Next in order are full size details from which to develop the patterns. Therefore draw one-fourth of the plan of the base joint, as in Fig. 15. It is necessary to draw the full size oblong base profile longer than the finished size will be in order to allow for drawing in the metal at the outer ends to fit the vertical collar on the

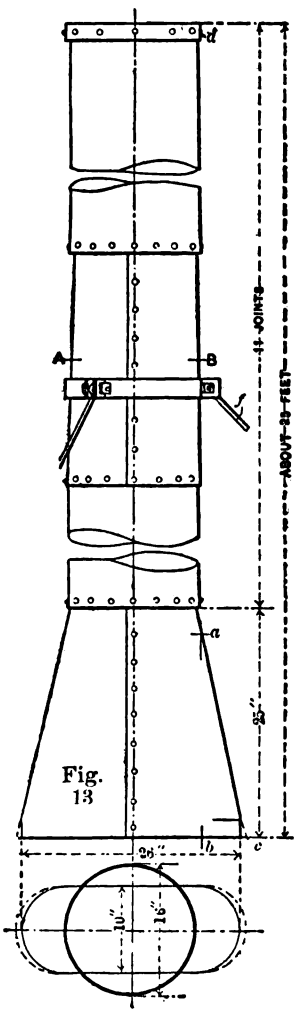

Fig. 14

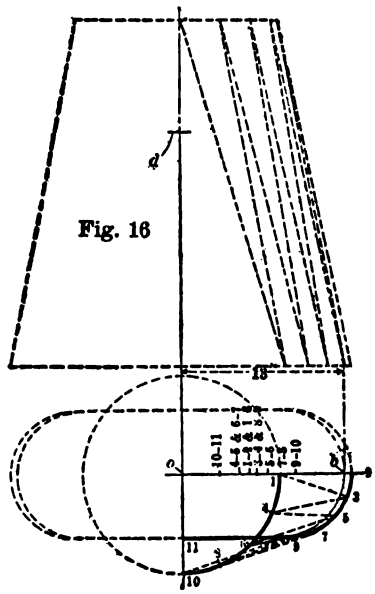

Fig. 15

Fig. 17

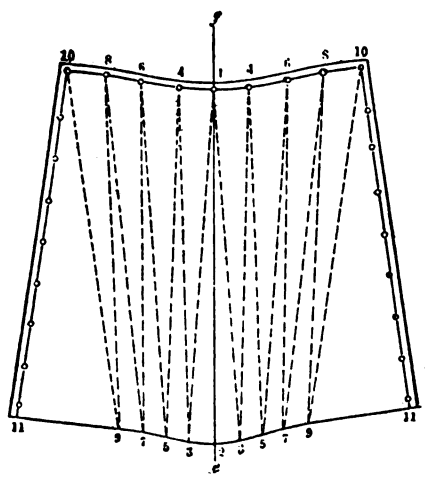

Fig. 18

Laying out Pattern for the Base Section of a Smokestack

boiler. As Fig. 13 has been drawn to scale, this difference is quickest ascertained by setting off the full hight of the boiler collar from the bottom of Fig. 13, intersecting the sloping side of the base joint, as at *a*. From *a* drop a perpendicular to the base line, as *a b*; then *b* 2 of Fig. 15 should equal *b c* of Fig. 13. This only applies of course where the flare of the base and hight of collar are not too great to

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admit of drawing in the metal sufficiently, as otherwise it is necessary to provide the base joint with a separate straight collar piece to fit over the boiler collar.

From *o* 2 in Fig. 15 draw a perpendicular, *o d*, equal to the straight hight of the base joint. (All pattern lines are net butt or rivet lines, and all laps are added to patterns afterward.) Space the top and bottom profiles of the base joint, as indicated in Fig. 15 by 1, 4, 6, 8, 10 and 2, 3, 5, 7, 9, 11, respectively, and from the point *o* set off on *o* 2 the several distances 1 2, 1 3, 3 4, 4 5, etc., as indicated. The dotted lines of Figs. 15, 16, 17 and 18 indicate the usual method of developing the pattern by triangulation, but while it is necessary to keep the lines in mind it is unnecessary to actually draw any of the dotted triangulation lines, as the solid lines and points thereon are all that are needed to give spacings or dimensions.

To develop the half pattern of the base joint, proceed as indicated by Fig. 18. The spacings 1 2, 1 3, 3 4, etc., of Fig. 18 of course equal the distances from corresponding points on *o* 2 to *d*, Fig. 15, the spacings 2, 3, 5, 7, 9, 11 of Fig. 18 equal corresponding spacings in the oblong profile of the base, Fig. 15, and spacings 1, 4, 6, 8, 10 of Fig. 18 equal like spacings in top or round end of Fig. 15.

The rivets in a stack of this size and gauge should be about 10 pound in size, spaced about 2 inches apart. The holes should be about 1-16 inch larger than the rivets to allow for inaccurate matching, and the rivets should be of sufficient length to allow for enough upsetting to completely fill the holes and provide good heads.

The next step is the development of the pattern of the round joints. Each joint is a frustum of a cone, being so tapered that the bottom of each joint fits over the top of the one below it, at the same time maintaining a uniform general diameter throughout the round portion of the stack.

As the angle of taper is so slight and the converging radius is consequently so great as to make it inconvenient, if not impractical, to describe the pattern as frustum patterns are usually struck—from a center—it is necessary to describe the arcs of the pattern without recourse to a center. Fig. 19 shows the proportionate shape of the pattern, but in order to more clearly illustrate the principles underlying its development the taper of the joint and consequently the curve of pattern arcs are exaggerated, as indicated in Figs. 20, 21 and 22, the actual taper necessary being about 3-16 inch, or the proportion shown in Fig. 13. In Fig. 20 *a c d f* represents an elevation of a joint turned upside down; *e b* is the center line and represents the straight hight; *a c* the diameter of the large end and *f d* the diameter of the small end. The arc *a g c* is developed as follows:

With the dividers locate *j* so that its perpendicular distance from line *d c* will equal its distance from *b*; from *d c*, perpendicularly through *j*, intersect center line,

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establishing g; draw the straight line g c; draw a line through j across and perpendicular to g c; locate k, so that its perpendicular distance from d c will equal its distance from j; from d c, perpendicularly through k intersect j J, establishing l; draw l c; through k draw a line across and perpendicular to l c; locate o so that its perpendicular distance from d c will equal its distance from m; from d c, perpendicularly through q, intersect k m, establishing p; draw and bisect a g; draw a per-

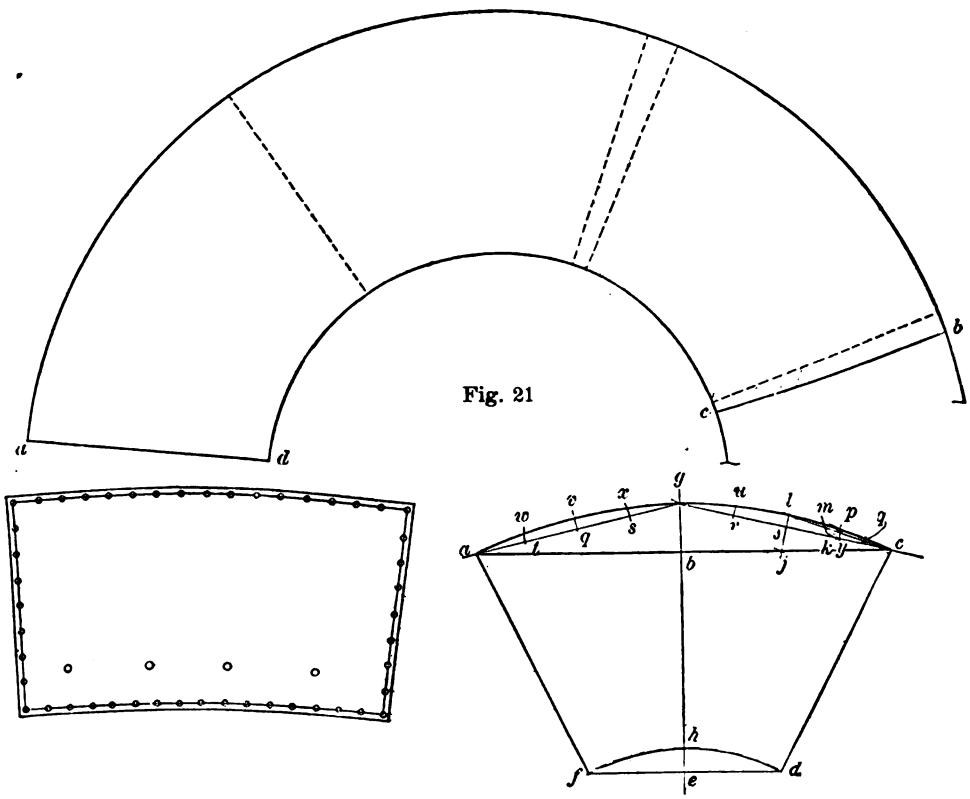

Fig. 21

Fig. 19. Fig. 20.

Shape and Development of Pattern of Base Section of Smokestack

pendicular through point of bisection q; make q v equal to j l; with a radius equal to J p strike arcs on each side of and with J and q as centers, intersecting g c and g a; from lines g c and g a set off on these arcs the distance y p, establishing u, x and w. A line traced through a w v x g u l p c is the true curve of the large end of the pattern. The curve of the small end is obtained by striking arcs from the large curve with radius equal to a f or c d and tracing a line through the same.

There is now a trifle less that one-third of the pattern. The full size stretchout is obtained by starting from a d and shifting and duplicating, as indicated by Fig. 21. The pattern piece should be shifted three times. Obtain the circumference of the large end of the pipe by multiplying its diameter by 3.1416, and measure it off

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on *a b*, the larger curve of the pattern; now place the pattern piece on the pattern with its outer curved edge coincident with the outer curve of the pattern and its straight edge at the circumference indicating point and scribe the line *b c*. Then *a b c d* is the net butt or rivet line of the pattern, to which a lap of $\frac{5}{8}$ inch must be added all around.

Fig. 22 is not used in practice, but is shown here merely to make clear the principles by which the arc *a g c* of pattern piece, Fig. 20, is developed. It will be seen that when A B C D is revolved around center *e* to the position of *a b c d*, or until its center line is where its side line was, *f g* and *h g* are equal and that *h a* equals the hight of the arc of which A B is the chord. The principle holds good with any radius or size of cone section.

Fig. 23 is the pattern of top band *d*, Fig. 13, which is laid off directly on the $2 \times \frac{1}{4}$-inch band iron. It will be seen that only alternate rivet holes are used, and that the lap of the band and the pipe seam are dodged by one rivet spacing. Fig. 24 shows the stack provided with a cap, the diameter of which is one and two-thirds and the hight one-quarter those of the stack. The distance from the top of the stack to the lower edge of the cap should equal one-half the diameter of the stack. When a cap is used the band *d* need only be $2 \times \frac{1}{8}$ inch, riveted only at the braces *e*. These braces should extend down into the pipe about 6 inches and be secured with a second rivet each. Fig. 25 is a section on C D of Fig. 24 and shows how the braces, seam in pipe and lap of band should dodge each other. Fig. 26 is a pattern of the cap, which is quickest obtained by striking a circle with radius equal to *f g*, Fig. 24, out of which take six times the difference between *f g* and *h g*, Fig. 24. To this should be added the laps. Space off rivet holes for braces *e*, as indicated.

Fig. 27 shows a pattern of $1\frac{1}{2} \times \frac{1}{4}$-inch braces, *e*. Fig. 28 shows the $2 \times \frac{3}{8}$-inch guide rod strap, made in three pieces, secured together by $\frac{1}{2}$-inch bolts, which also pass through eyes formed in the ends of the $\frac{3}{8}$-inch guide rods. It is only necessary to lay out one-third of Fig. 28 full size to develop the straps (see Fig. 29.) Fig. 30 is a pattern of one piece of the strap. Fig. 31 shows how the eye should be formed in the guide rods.

If the punch with which the rivet holes are to be made is provided with a center point the rivet spacings of the pattern should be prick marked, or centered, only, and the material be likewise pricked, or centered, from the pattern, but otherwise the rivet holes in pattern should be accurately made with a punch about 1-16 inch larger than the punch that will be used on the material and the holes carefully scribed onto the work. Thus the thickness of scribe is allowed for, so that the circles are about the size of the punch, making centering easier.

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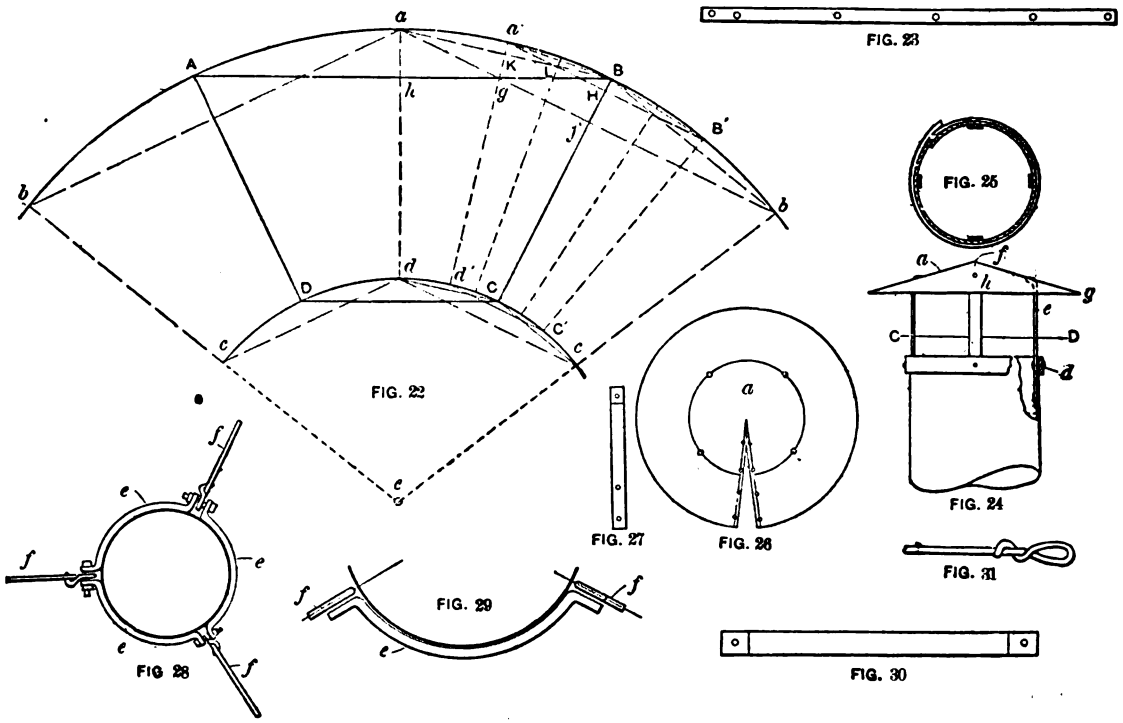
After cutting, punching and forming in the machine rolls, the next step is to rivet the longitudinal seams in each joint separately. Next assemble the stack by riveting a round joint to the base joint; then add round joints until the entire stack is put together in one piece, which is possible in this case, the length being only about 25 feet and weight not exceeding 300 pounds. In riveting together the joints of such a stack a straight piece of railroad iron, firmly secured in a perfectly horizontal position and projecting about 5 feet into the stack, makes a good mandrel. Such a mandrel, together with an overhead track carrying a roller from which is



Patterns for Minor Parts of a Smokestack

suspended a chain tackle for supporting the stack in a horizontal position, makes it comparatively easy to rivet the joints together quickly and accurately.

In a job of this kind the accuracy of the patterns entirely governs the facility with which the work can be put together, thus it is essential that the pattern be made absolutely correct in every particular before any material is marked out. When the stack is dry, after receiving two coats of black asphaltum paint, the simplest way to set it up is as follows:

Provide one good man with three strong helpers, plenty of ¾-inch guide rope, a block and tackle hoist and two strong 18-foot ladders. After delivery to building the four men can hoist the stack on the roof by hand; next attach the strap and

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guide rods and lay the stack over the hole in the roof, with the hole about midway of the stack. Now lay the ladders one on top of the other, tie the upper ends together and secure the tackle and two guide ropes thereto. Raise the ladders to a vertical position and spread the bottoms about 8 feet apart, locating them so that the tackle will hang vertically over one side of the roof opening. Secure the ladders in this lean-to upright position with the two guide ropes tied to the most convenient hitchings. Wind a rope several times around the stack just above the middle, form a slip noose and hang on the tackle. Hoist the stack until the lower end can be inserted and lowered through the roof opening and connected with the boiler. Now permanently secure the guide rods to convenient hitchings (previously provided), ascend one of the ladders and disengage the rope from the stack, lower the ladders and make the connection between the roof and stack, as described in Volume III.

FACILITIES FOR WORKING WROUGHT IRON

A majority of the shops that do general sheet metal work find it necessary to use and work a considerable quantity of bar and heavy sheet iron, but comparatively few are adequately equipped for such work. The average equipment consists of a small forge, a vise, a brace bender, a hand punch, shear and drill, and, possibly, a very small shallow throated power punch, all in more or less dilapidated condition, and with the forge so located as to be inaccessible for heating any other part than the ends of bars, etc.

This general failure to provide adequate facilities for economically turning out this part of the work may be accounted for by the assumption that this branch is not important enough to justify any considerable investment in machines or floor space. It has been found that one large deep throated combination power punch and shear, with plenty of dies, benders, shears, etc., is worth more than any number of small inadequate tools without proper dies.

Some concerns make the mistake of spending several hundred dollars for a machine of ample power and throat capacity, and then fail to get all the attachments that can be used to advantage with it. In one instance a certain concern took a contract that required the punching of a considerable number of 1½-inch holes through ⅛-inch metal, and while they had a machine of sufficient capacity, the 1½-inch punch and die were lacking, and, rather than spend the price of the same, they chewed out the holes by using a small punch and punching a circular row of holes, and then filed up the jagged edges, which cost more in extra labor than the

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new punch, and did not produce accurate work. In another case a party made ⅜-inch square holes by punching ⅜-inch round holes and squaring with a file.

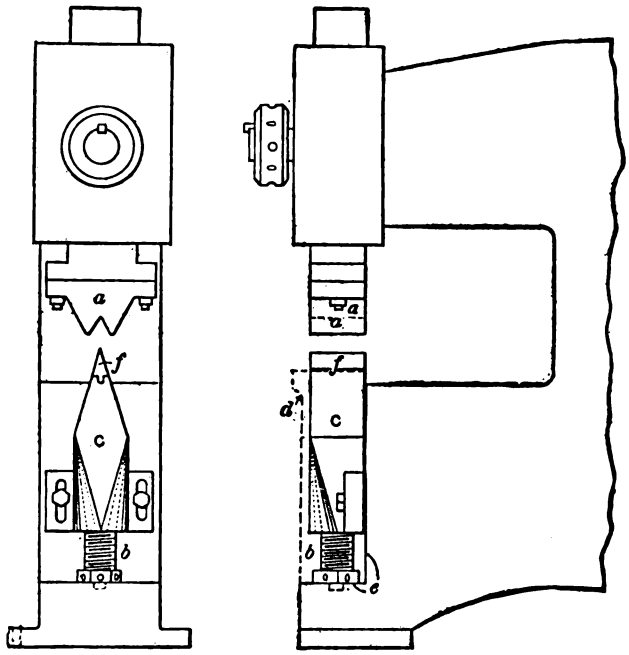

Fig. 33. Fig. 32.

An Ideal Machine for Working Wrought Iron

In both of these cases the parties argued that they had such little use for such dies that it would not pay to buy or make them. At the same time they spent their cost in extra labor, which would have been saved if the dies had been secured and used. Moreover, they would have been on hand ready for any more of such work. It pays to have every attachment that can be used to any advantage on any machine.

For a shop doing general cornice work a machine of this kind should have a capacity of cutting $3\times3\times\frac{1}{4}$-inch angle iron, which strength would also meet any other shearing, punching and bending requirements in the construction of roofs, curbing and any miscellaneous structural framing likely to be encountered by the cornice makers. The principal attachments and tools needed are: Bar shears, with gauge; splitting shears, with gauge; round iron shears; angle iron shears; punches, closely graduated from the largest to the smallest ever used, taking care to keep on hand several sets of each size of the small punches and those sizes most used, and any special punch such as square, oblong, slot shaped, etc., likely to be needed.

A special bending tool that has been found extremely useful in connection with a power punch and shear is shown in the illustration, Fig. 32, which is a broken side view of the machine, showing the bender in position, and Fig. 33, which is a face view of the machine and bender. In order to use this tool the dotted line portion *d* of the lower jaw, or bed, of the machine must be removable, so that the bender can be placed directly under the plunger, or vertical acting head, to which is bolted the upper inverted V-shaped die *a*, made of cast iron. The lower die consists of two members—*b* and *c*. *b* is a stud about 2½ inches in diameter, hexagon shaped for about 1 inch at its lower end, which rests on the

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ledge, from which the block *d* is removed, and is provided with a short tenon which sockets into the ledge to keep the stud in place. *C* is of cast iron, into which the stud *b* is threaded about 8 inches. It is provided with slotted flanges on each side for bolting to the face of the machine bed, is tapered off in wedge shape at its upper end and is finished with a hatchet shaped steel point, *f*.

It will be seen that by turning the stud *b* the member *c* can be raised or lowered, in order to produce any desired angle in bending, in the same way that one member of a vertical acting cornice brake can be adjusted to produce any angle when forming molded work. This bender bears the same relation to wrought iron work, especially cornice braces, as compared to an ordinary brace bender, as the upright cornice brake bears to cornice moldings, as compared to a hand brake.

PATTERN FOR SIDE OF BOILER BREECHING

This problem is of frequent occurrence and the following is an explanation of how to lay out the pattern for the side of the breeching against which the clean out door closes, opposite the flues in a power boiler. Fig. 34 shows the boiler with the breeching which leads to the smoke stack in position. In Fig. 35, O P in the front elevation represents the circumference of the boiler, F B D the breeching and A B C D E the clean out door, while in the side elevation E′ E 4 4′ represents the side of the breeching, which is represented in the front elevation by A B C D E. As the two halves are the same, it will be only necessary to find the pattern for the one half, C D E.

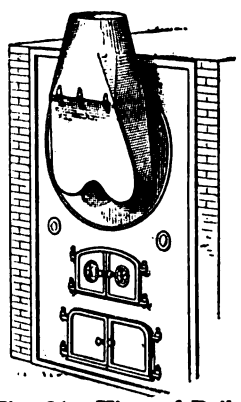

Fig. 34. View of Boiler and Breeching

Divide the curved part of the half front elevation C D E into a number of equal parts, as shown by the small figures. From these points and from the point E draw horizontal lines into the side elevation, intersecting the clean out door and the side of the boiler, as shown by similar letters and numbered points. Then draw in Fig. 36 the stretchout line C E, on which lay off the stretchout of C D E in Fig. 35 in front elevation, as indicated by similar letters and figures on the stretchout line in Fig. 36. Through these points draw lines perpendicular to C E, send on the lay off the distances as obtained in the similarly numbered letters in

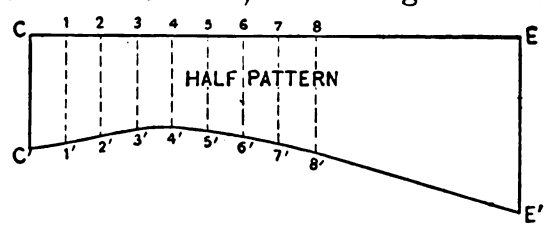

Fig. 36. Laying Out the Pattern

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the side elevation. Draw lines through the points thus obtained. Then will C E E′ C′ be the half pattern desired. The pattern for the door would be laid out by

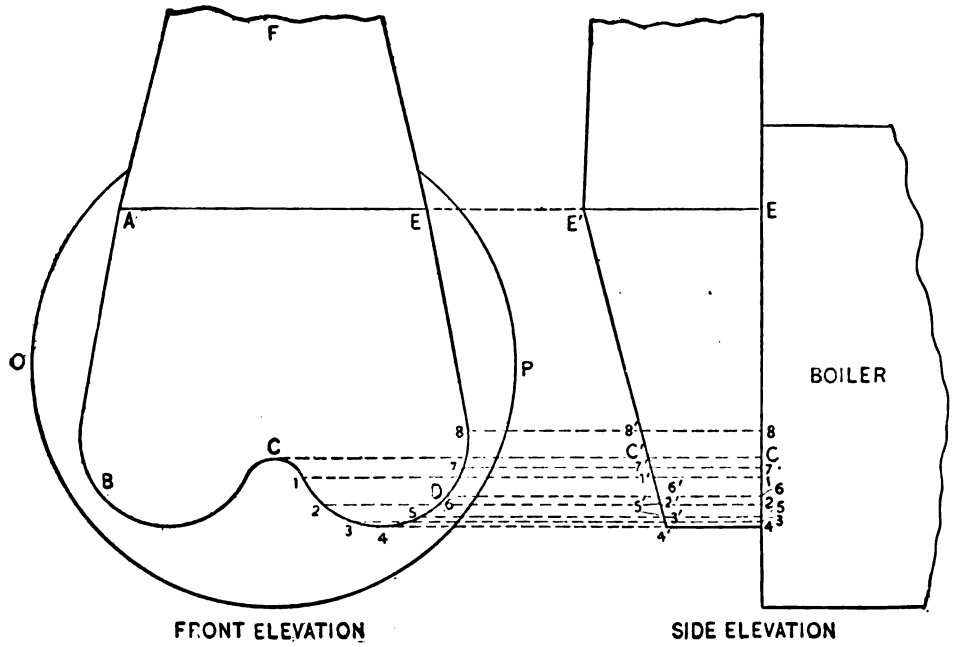

Fig. 85. Obtaining the Developing Lines

the principles explained in problem 37 of "The New Metal Worker Pattern Book," in which the opening in the flange is, referring to this problem, the pattern of the door.

PATTERN FOR A PIPE BRANCH WITH ITS TWO PARTS JOINED

Of the many problems submitted for solution in the pipe work, this is worthy of especial consideration, by reason of it requiring the seams to be along the lines *a b* and *c d* of Fig. 37 and to have the pattern in halves—one half of F and one half of E in one piece. This condition as imposed does not complicate the pattern; on the contrary it simplifies it and what is more important it allows of great ease in uniting the parts together. In the first figure are reproduced the inquirer's sketches as shown by the heavy lines, and for a clear conception of the article the views were drawn complete. The developing of the patterns for this branch would not be extraordinary, for part F is simply the frustum of a right cone intersected by a scalene cone E, were it not that it is required that the seams be as aforesaid. As the pattern line at the intersection would ordinarily be a curve, these two halves of the pattern could not then be in one piece; hence the intersecting plane, the

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edge of which is represented by the line *f g*, Fig. 37, must be bounded by straight lines (as shown fore-shortened by the dotted triangle *h*, *i*, *j*, of the front elevation), which will give a straight joining line for the two parts of the pattern.

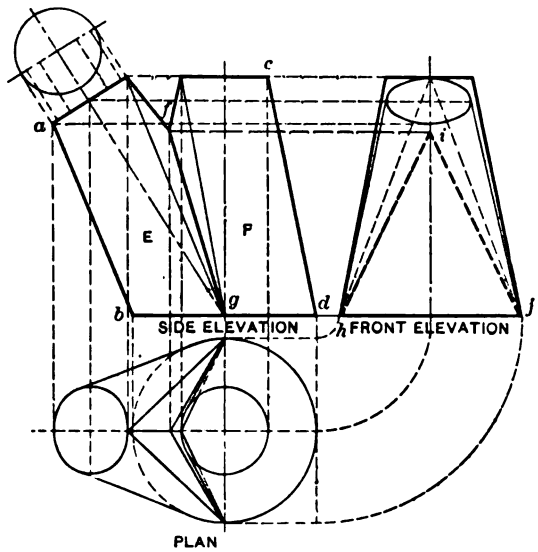

Fig. 37. The Problem as Submitted

The problem thus rests as a geometrical figure with a contour composed of various shapes; the portion of F, Fig. 38, from 11 to 14 and 18 to 21 is part of a right cone; 18 and 8 to 11 is a curved surface the elements of which diverge from 18 and there is a flat plane, 18 and B to 8. The same can be said of E except that the portions from 1 to 4 and 15 to 18 are parts of a scalene cone.

The usual method of developing the surface of the shapes stated will not be used, such as finding the outline of the conical surface by radial lines, but by triangulation throughout; therefore, draw the side elevation as in Fig. 38 with one half of the profiles placed as shown. Divide these profiles into a like number of spaces and connect 15 to 18 and 1 to 4 with solid and dotted lines and 4 to 7 and 18 with solid lines. Repeat for F.

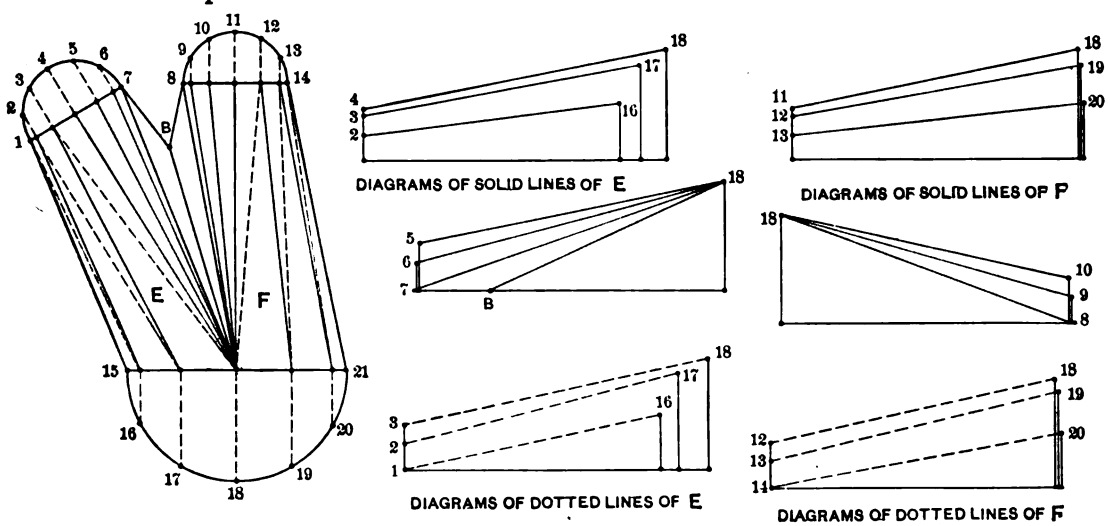

Fig. 38. Elevation, Profiles and Diagrams in Obtaining Pattern for Pipe Branch

The ascertaining of the true length of these lines is accomplished by a system of diagrams which if followed carefully step by step should be self-explanatory. That is, the lengths of the solid and dotted lines as given by the side elevation are

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placed on the base line and from these points perpendiculars are erected of a length coinciding with those of the profiles. The lines connecting correct points will be the exact length of the lines shown in the side elevation, as 17 3 of E is true on 17 3 of the diagram of solid lines.

Since the lines 1 15 and 14 21 are indicated in their true lengths in the side elevation and as the seams are wanted on those lines the pattern is started by drawing anywhere a line equal to 1 15, as in Fig. 39, and from point 1 with compasses set to 1 16 of diagram of dotted lines strike small arc and from point 15 with bow dividers set to the space 15 16 prick off on the line just drawn, the point 16; and so on to 4 18. Then from 18, the various lines of the diagram for this part are struck and then stepped off with the bow dividers adjusted to 1 2. Likewise B and 8 are struck from 18 and the space 7 to B to 8 of the elevation set on these arcs. The surface F is obtained in a similar way.

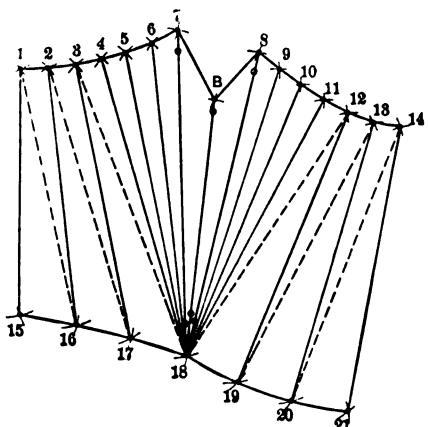

Fig. 39. The One Half Pattern

When forming up this pattern slight bends are made, in the same direction, one line 18 to 7, another 18 to 8 and the third 18 to B, being reverse of the curved parts.

ASCERTAINING MITER LINES OF ELBOWS IN DISCHARGE PIPING OF CONVEYOR SYSTEM

One of the frequent requests received by *Metal Worker* is that for finding the true angle in a change in direction in piping. In Fig. 40 is reproduced a sketch submitted by a correspondent, for the developing of the miter line and pattern for the elbow of conveyor piping at the junction of pipes A and B at C. He also desired information as how to develop the cut of the openings of the corrugated window fills. To make it of utmost interest to the other readers, all miter lines and openings are here developed.

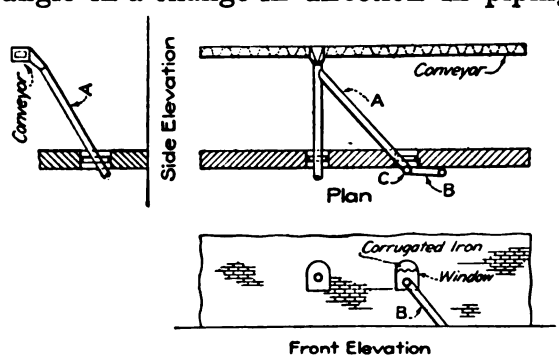

Fig. 40. Problem Submitted by Correspondent

The first essential in laying out work of this class is correct measurements of the building, giving all data, such as the hight of ceiling, distance conveyor is from

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the windows or wall and the like. A plan and oftentimes two elevations are drawn to a scale. In these various views the piping may be sketched in, as indicated in Fig. 40.

With this information at hand, and knowing that in problems of this sort the form of the object or objects is neglected for the time being, and only the center or rather axial line utilized as working material.

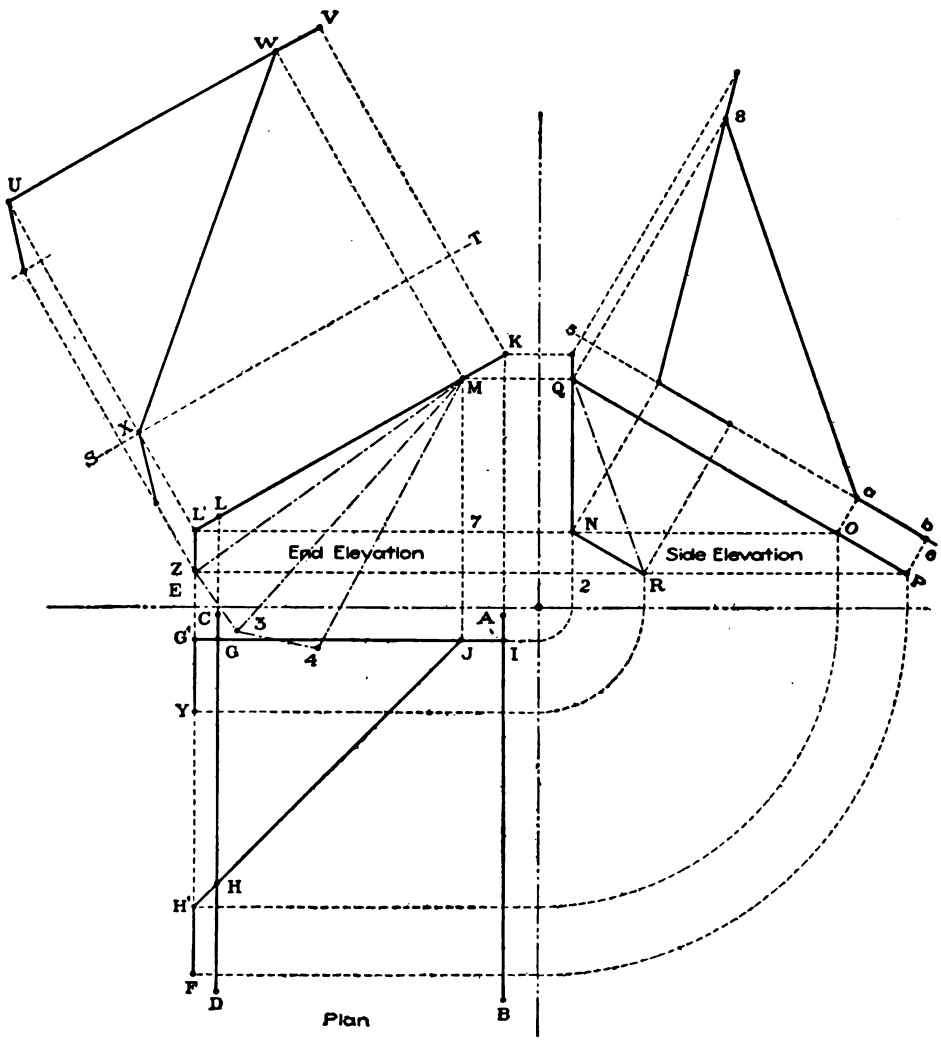

Fig. 41. Diagram of Steps in Determining True Angles of Piping

Referring to Fig. 41, therefore, a line A B representing the conveyor in plan is drawn. As the conveyor is parallel to the wall through which the piping passes, another line as C D represents this wall. This line will not be the axial line of the oblique pipe, inasmuch as the diameter of the pipe is to be taken into account. Accordingly, another parallel line the distance away from the wall equal to the

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radius of the pipe is drawn, as E F. From the data the centers of the windows G and H are located on line C D, also point I on the conveyor line. A line drawn through points I and G from A B to E F will be the axial line of one run of piping. The point of intersection of the other run of piping with this is fixed where required, as at J. From J then, through H to line E F, draw a line to be the axial line of the run of piping labelled A in Fig. 40.

The line of the conveyor in the end elevation is now indicated by the dot K. This is to be the hight above window openings as called for by the data. The window openings are shown by the dot L. The piping is indicated by the axial line in elevation from K to L′ and the point of intersection by M.

A side elevation is projected to the right, as shown, in which N and O are the center points of the elbows, and O P the line of piping designated as B in Fig. 40. In this case the slope of O P is such as to have the line of piping O P lie in the same plane in this side elevation to the line of piping O Q, which is H′ J in the plan; it is to be remembered that this slope is governed in practice by the data. The correspondent does not state how the piping G J of Fig. 41 turns after passing out the window, but for enhancement of this article it is assumed that it passes down the side of the wall, as N R parallel to O P.

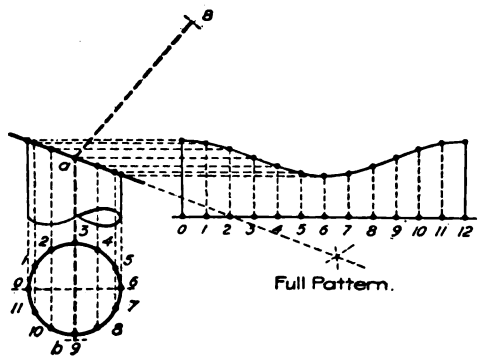

Fig. 42. Development of Pattern of Elbow C in Fig. 40

With this much of the elevations and plan the true angle of the intersection of the two lines of piping can be ascertained, though again he does not require this. Before going any further, it is well to remark that a practical suggestion is not to branch two lines of pipe in the manner he indicates in Fig. 40. Instead, a fitting should be made which is a transition from the shape of the conveyor to an ordinary fork about as sketched in Fig. 43 in the upper corner of the illustration.

Parallel to line L M K draw a line as S T; from this the distance G H draw another parallel line as U V. Project the points L′ M and K to these lines as shown. Then U V will be the true length of G^1 I and point W the true position of the point of intersection of the two lines of piping. Then W X will be the true length of line H^1 J. Also U W X is the true angle of the intersection at W.

For determining the angles of two lines not shown true in any view, as the angle J G^1 Y in the plan of Fig. 41, an expeditious method would be to assume that

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M L′ Z (or Q N R) is a triangle. Granting this much, the next operation would be to lay this triangle flat; that is, view the plane in which the triangle lies at right angles. This can be most readily accomplished by first learning the exact length of side of the triangle M Z. To do this, erect a line at right angles to line Z M and from Z the length of 2 R, as Z 3. Knowing that N R lies in a plane viewed at right angles, and is therefore its true length, the next step would be to swing an arc of the radius of this length from 3. Again, knowing that L′ M is the true length of the line Q N (or G^1 J) an arc of this length as radius is swung from M to intersect the first arc, establishing point 4. Hence, M 3 4 is a full view of the mentioned triangle and 3 4 the true angle of J G^1 Y.

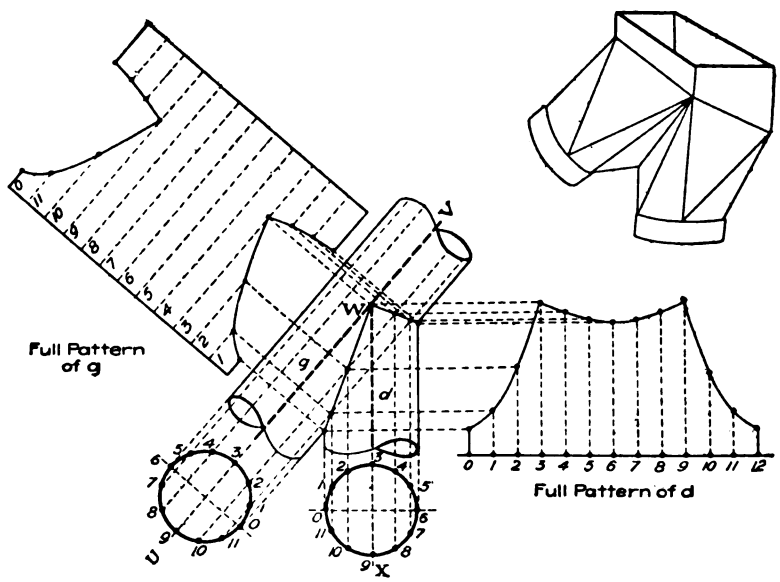

Fig. 43. Development of Pattern for Two Pipe Connections and Suggested Alternate

Another method of finding the true angle, that of J H^1 F, may be indicated by projecting an oblique plan from the side elevation in this manner: Parallel to Q P draw a line at 5 6. Project the points Q O P to this line, continuing the line from Q indefinitely. Take the distance L′ 7 in the end elevation and place it on the line from Q, giving point 8. Where lines from O and P cut line 5 6 will be called *a* and *b*; and a line drawn from 8 to *a* and *b* will be a true view of J H^1 F and, of course, the desired true angle.

For the pattern of an elbow of this angle, transfer line 8 *a b*, as in Fig. 42. The rest of the procedure is of such everyday occurrence that further explanation is unwarranted. Similarly, the procedure for the branch is as shown in Fig. 43.

For the openings in the corrugated window fills, a suggestion is that the opening be laid out on a flat piece of metal, then this template laid on the corrugated iron at the correct position and the opening scribed thereon. In Fig. 44 the axial line L M K in Fig. 41 is reproduced, also the line L M. And in the plan, the axial line H J in Fig. 41 is represented by H J in Fig. 44, together with line C D. For the opening at G, the profile of the pipe S is divided into spaces and the usual

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parallel lines drawn to line L' Z, thence horizontally to the left indefinitely. Erect any vertical center line as X T and from both sides of this line place the distances of the profile; for instance, 6 O in the profile is 6^1 O^1 in the template; and so on, realizing the elliptical figure as shown for the opening.

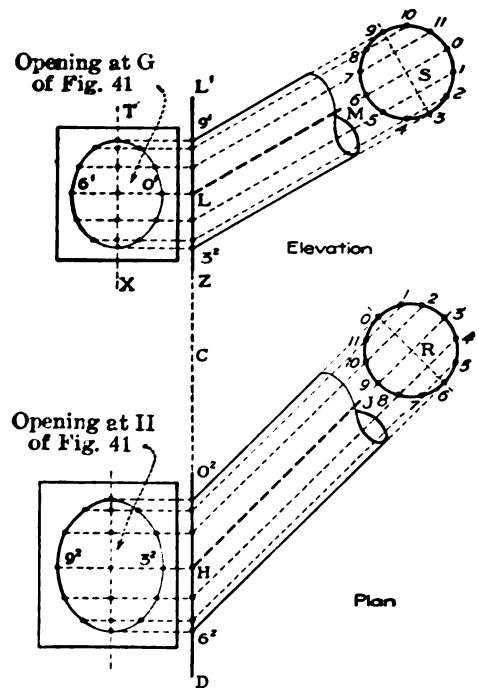

Fig. 44. Method of Cutting Opening in Window Filling

In like manner divide profile R and project lines to line C D, thence to the left and vertical center line erected. Instead of taking the distances from profile R as was done for S, it is to be remembered that line H J is at an angle to C D, both in elevation and plan. In consequence, while the spaces, as O 6 of profile, are each at O^2 6^2, the distance 9 3 is greater. Imagine that line H J is the edge line of a plane as wide as 9 3 in profile R. This plane in elevation is 9 3 in profile S, and would be cut obliquely at L^1 Z as 9^1 3^1. So much decided, this distance is carried to the vertical line for the opening at H, as 9^2 3^2. The process as outlined is repeated until the points for the elliptical opening are obtained as shown in the illustration, Fig. 44.

A BOILER FLUE CONNECTION PROBLEM

This problem deals with a connection between the smoke outlet of a boiler and the flue hole in a chimney at a higher level and offset from the position of the boiler. The furnace collar is of the oval shape, and in a relatively short distance the smoke connection is to be changed from the oval to the round in order to fit into the chimney. As explained in the following discussion, the idea has been not to treat the question as one to be worked out by a special application of sheet metal pattern drafting, but to attempt to make the offset with the use of elbows or parts of elbows, such as one is likely to have in stock for general pipe requirements.

In preparing the answer to the foregoing inquiry the author had in mind, as a result of a considerable experience in these lines, that no employer will allow his foreman the time to lay out fancy fittings, by reason of his inability to ask his customer a price to cover the time to lay out and make and likewise connect smoke

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pipe built on such lines. Hence, due thought was given to describe everyday practice.

The sketch, Fig. 45, shows a boiler with an oval $9\frac{1}{2} \times 14\frac{1}{2}$-in. collar connecting to a 12-in. round flue opening, which is a given hight above the collar and to the right of it when viewed from the front of the boiler.

After the boiler is set in its permanent position the measurements can be taken in this manner: With a stick held level and in the center of the boiler collar, also square with the face of the chimney and of a length to touch the chimney (assuming that the boiler is set square with it), establish the point *d* in Fig. 45. Drawing a level line from this point on the chimney to a line dropped plumb from the center of the flue gives the offset to the right and the vertical rise from the boiler collar to the flue opening. These measurements are jotted down in a sketch like Fig. 45, not forgetting the distance the boiler is from the chimney on a line perpendicular with the face of the chimney. The boiler collar is measured for both diameters and the girth found by winding a thin strip of sheet metal around the outside of the collar. For a positive shape of this opening an ellipse is not drawn geometrically, for who knows if the collar of the boiler was so laid out, but a piece of paper is held against the collar and the hand rubbed over it; the collar being dirty, an impression of the collar is obtained on the paper. These data are taken to the shop.

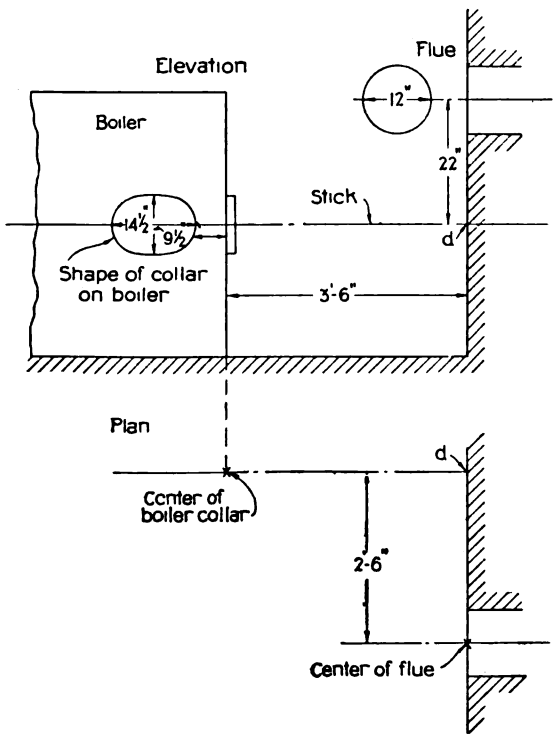

Fig. 45. Relation of Boiler and Chimney

To a convenient scale construct a side elevation of the job. That is, a vertical line will represent the boiler as indicated in Fig. 46, with a horizontal line for the center of the boiler collar. At a distance of 3 ft. 6 in. from the vertical line erect another for the chimney, and 22 in. from the horizontal draw horizontal line for the center of the flue opening; these horizontal lines continue indefinitely to the right.

It is customary for work of this nature to have fittings as near standard as possible, and if special ones are required to design them with the expectation of using

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them on other jobs; for the transition, therefore, a simple oval to round shape is employed as shown in elevation by B and as a plan at C. This, to take up as little room as possible, is made with 2-in. collars and 6 in. from one profile to the other or *a* to *b* of elevation. On the lower horizontal line *s t* to place point *c*,

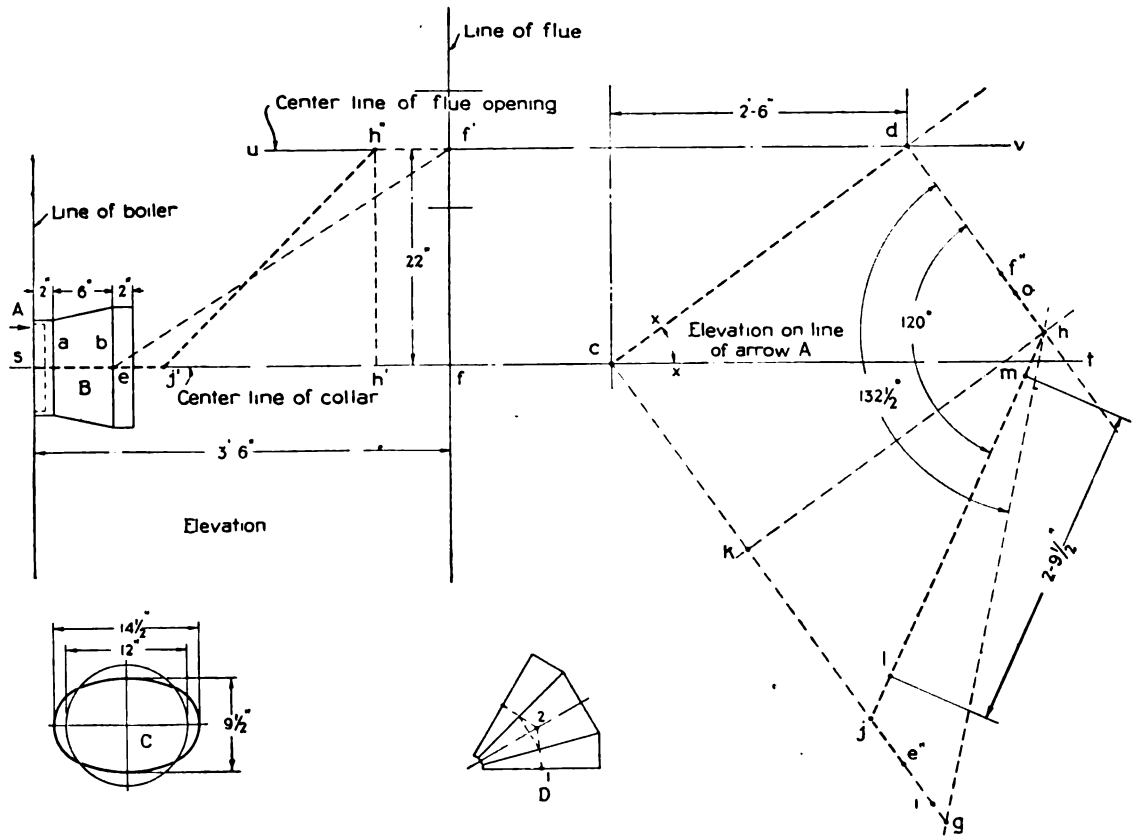

Fig. 46. Method of Determining the Length and Angles of Smoke Connection

erect a vertical line crossing the upper horizontal line *u v*, then to the right of this 2 ft. 6 in. from the line just drawn make a dot. These dots *c* and *d* are end views of the horizontal axial lines of the lines of pipe, inasmuch as a line is shown by a point when viewed on end. Connecting these points gives a line depicting the axial line of center section of the line of pipe seen on line of arrow A.

Parallel to *c d* draw a line for the base of a triangle, as K *h*. Lay off from K on *c* K to the point *g*, so that K *g* is equal to *e f* of elevation. Then *g h* is the true length of *e f'* of elevation; that is, the axial line of the middle section of the pipe connection. As standard fittings are to be used and as the throat of the elbows will require some space, the points are moved along the lines *s t* and *u v* respectively, or what is the same thing, on line *g c* and line *h d*. As this moving of the points is a changing of the angle *g h d*, point *h* may remain stationary.

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Now, as the nearest standard fitting is a 45-deg. elbow, make angle *g h d* such, which establishes point *i*. Obviously this transposing of *g* to *i* does not give sufficient space for the elbows on the horizontal lines *s t* and *u v*, so a little calculation is performed, and as it is not advisable to make a turn of greater than 45 degrees with a two-piece elbow, it is decided to employ the first, last and one of the middle sections of a four-piece 90-degree elbow, D, which leaves an angle of 120 degrees and consequently establishing point *j* as indicated.

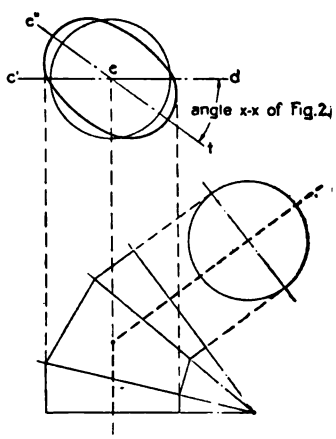

Fig. 47. Style of Fitting for Smoke Connection

So long as the distance *j k* is maintained, the locating of the points on the lines *s t* and *u v* is arbitrary; therefore point *j'* of the elevation is a distance from *e* of one half of the elbow B, allowing for the collar and an ample joint. This fixes the point *k'* (the distance *j k* of the oblique elevation) and thus the point *h''*. While this line *j' h''* is not essential, the process of obtaining it requires but a few minutes and aids the draftsman in his mental conception of the article.

The elbow D is used at both *h* and *j*. As indicated, it leaves a distance *l m* on the line *j h* that calls for a length of pipe of 2 ft. 9½ in., to which must be added an allowance for the lap of the joint. And a small piece from *o* to *b''*, with about 2 in. to go in the flue, and also allowance for lap must be provided for; say, about 1½ in.

The author of this article, together with several of his comrades in the trade, has always endeavored to lay out pipes for all classes of work just as one would erect the lines of pipes in steam or hot water heating. Simply because a line happens to have some unusual turns the steam fitter does not attempt to devise special fittings, but gets over his difficulty with what he has at hand. Should you have a dozen boilers all set differently, you could use the fitting B with suitable angle elbows to realize the offsets. Still if you really desired to accomplish the transition in the angle piece on the angle *g h d*, the process is as outlined in Fig. 46, only moving point *j'* a distance from the boiler collar to permit of an easy turn and taking the distance *j' k'* to the oblique elevation to get the true axial distances.

The profiles are placed with the center line of the round on line *c' d*, Fig. 47, and the center line of the oval on line *c' t*. Projecting to the oblique elevation one will have a fitting like that shown in Fig. 47. A round pipe elbow of the same angle is required for the flue or at *h* of Fig. 46.

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PATTERN FOR A TAPERING ELBOW

For an accurate method of cutting the patterns for a two or more pieced tapering elbow, where the difference in the sizes of the ends is so small that the dividers or trammels cannot reach the long radii required by the cone method and also adaptable to elbows of heavy metal, the following exemplification applies:

The method to be employed in this case is that of triangulation. The patterns for a two-pieced tapering elbow will be developed. The same principles may be

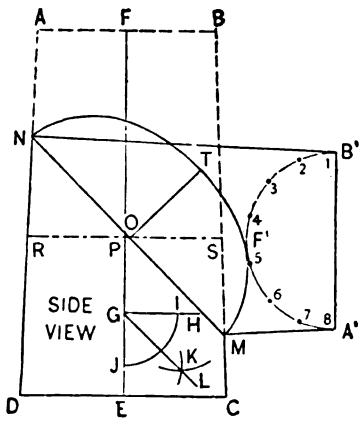

Fig. 48. Obtaining Miter Line and True Section

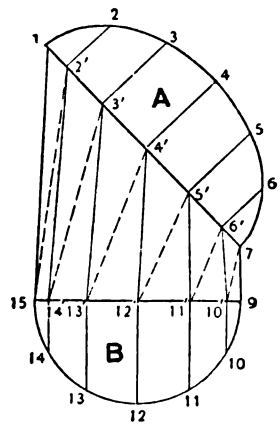

Fig. 49. Measurements for Sections

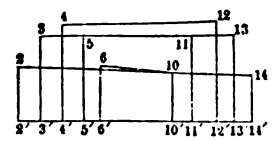

Fig. 50. Sections on Solid Lines

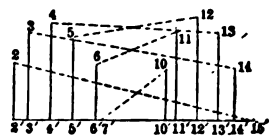

Fig. 51. Sections on Dotted Lines

applied to any angle or number of pieces. Let A B C D in Fig. 48 represent the section of a tapering pipe to be cut by the line M N so as to form a square tapering elbow when reversed and joined together, as shown by C D N B^1 A^1 M.

To obtain the line M N proceed as follows: Draw the center line F E, as shown, on which locate any point, as G. Draw G H parallel to the axis of the second piece of the elbow. Bisect the angle E G H. Next locate the desired hight C M, and from M, parallel to G L, draw the line M N. Take a tracing of N A B M and place it reversed on N M, as shown by N B^1 A^1 M. The sections on B^1 A^1 and C D are true circles, but the section on N M is an ellipse, which is obtained as follows: Through O, the center point of M N, draw the horizontal line R S. At right angles to N M, and from O, draw O T, equal in length to P R or P S. Through N, T and M, draw the semiellipse.

Take a tracing of N M C D and place it in Fig. 49, as shown by 1 7 9 15. On 1 7 place a tracing of the semiellipse, as shown by 1 4 7. On 9 15 draw the semicircle 9 12 15. Divide both the semicircle and semiellipse into the same number of equal spaces, as shown by the small figures. At right angles to 1 7 and from points 2, 3, 4, 5 and 6 draw lines intersecting 1 7 at 2′, 3′, 4′, 5′ and 6′. In

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similar manner, at right angles to 9 15 and from points 10, 11, 12, 13 and 14, draw lines intersecting 9 15 at 10′, 11′, 12′, 13′ and 14′. Draw solid lines from 2′ to 14′, 3′ to 13′, 4′ to 12′, 5′ to 11′ and 6′ to 10′; and dotted lines from 2′ to 15′, 3′ to 14′, 4′ to 13′, 5′ to 12′, 6′ to 11′ and 7′ to 10′. The exact, or true length, of these lines will be determined by constructing a series of sections, the bases of which are the aforesaid lines and the outer sides or ends to be coincident in size to like numbered lines of the semiprofiles, A and B. The connecting lines to these or rather, the remaining side of the sections will be the required lines of true length. The mentioned sections are constructed as follows:

In Fig. 50 draw any horizontal line, as 2′ 14′, upon which place the lengths of all the solid lines shown in Fig. 49. From these points, on and at right angles to 2′ 14′ in Fig. 50, erect lines equal to the altitudes in the semiprofiles in Fig. 49 having similar numbers. Draw lines connecting the ends of the proper vertical lines. These will represent the actual distances on the finished article, of similarly numbered lines in Fig. 49. In precisely the same manner obtain the sections on dotted lines in Fig. 49, as shown in Fig. 51.

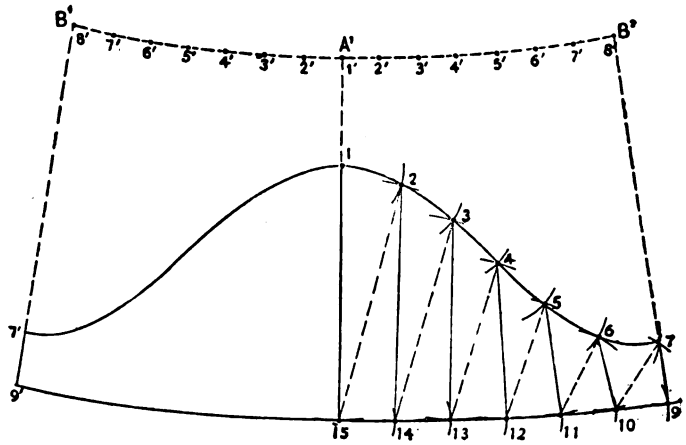

Fig. 52. The Patterns

For the pattern, draw any vertical line, as 1 15, in Fig. 52, equal in length to 1 15 in Fig. 49. With 1 2 in A as radius and 1 in Fig. 52 as center describe the arc 2, which intersect with an arc struck from 15 as center and 15 2 in Fig. 51 as radius. Then with 15 14 in B in Fig. 49 as radius and 15 in Fig. 52 as center describe arc 14, which intersect by an arc struck from 2 as center and 2 14 in Fig. 50 as radius. Proceed in this manner until 7 9 in Fig. 52 has been obtained, which is measured from 7 9 in Fig. 49. Trace a line through the intersections obtained in Fig. 52; then will 1 7 9 15 be the half pattern for the lower arm of the elbow.

As the elbow has an equal taper throughout, the pattern for the upper arm A^1 B^1 N M may be obtained by extending 15 1 in Fig. 52 indefinitely, as shown, and making 1 A^1 equal to M A^1 in Fig. 48. Through A^1 in Fig. 52 draw the curve A^1 B^2 parallel to 15 9. On A^1 B^2 lay out the stretchout of the half section on A^1 B^1 in Fig. 48. In Fig. 52 continue 9 7 to 8′. Then will 1′ 8′ 7 1 be the half pattern of the upper arm. Trace this to the left of A^1 15 for full pattern.

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METHOD OF SUPPORTING SHEET METAL FLUES

In the ventilation of large buildings where sheet metal flues are carried up from the basement to furnish means for the distribution of air to rooms desired, there are numerous little kinks which greatly facilitate the work, but are usually developed by experience. Of course, the majority of the forming is done either at the shop or in temporary quarters located on the job, if it is a big one, but it is inconvenient to handle ducts which are usually 20×28 in. in size or thereabouts, in lengths of over 14 ft. Consequently arrangements must be made so that pipes can be readily entered one to another.

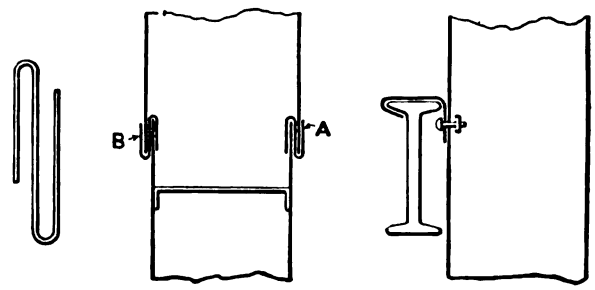

Fig. 53. Fig. 54. Fig. 55.
Erecting and Supporting Ventilating Ducts

In Fig. 53, a section is shown of a device which is used to facilitate this work. These bent pieces of sheet iron are slipped over each piece of pipe in such a manner that the inside loop hangs over the lower piece of pipe, while the outside piece of pipe is ready to receive the upper piece of pipe. This is shown more clearly in Fig. 54, which gives a rather exaggerated section of the top of the pipe indicating the taper, but it serves as an outline to illustrate the method of fastening, making obvious the ease with which work can be erected by this method. At the points marked A and B in Fig. 54, a hole is drilled through all the sheet metal work with a fiddler's drill and a common wood screw inserted, after which the ventilating ducts can be handled and lifted with little or no danger of their coming apart. Of course, after the ducts are finally in place they are riveted together, but this forms a temporary holding power. There are numerous other forms of "slips"; but these are the fundamental principals of all and the most popular.

In some cases long vertical ducts are supported from the bottom, but this is not desirable in many cases, as it throws the entire load at one point, consequently the method shown in Fig. 55 is frequently employed. A band of iron usually ⅛ or 3-16 in. in thickness by 1¼ in. broad is hooked over a steel I beam or some other substantial part of the building framework, and turned in such a manner that a bolt may be passed through this and the sheet metal work, giving it support on either side. These supports are usually made at every floor of a building, but staggered on either side of the ventilating duct so that support is afforded both sides of the pipe.

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HEAVY METAL PATTERNS FOR PIECED ELBOWS

This treats of a method of obtaining the patterns for an elbow, made of any number of pieces out of heavy material, so as to get the large and small diameters of each piece, the miter joints to be riveted as shown in Fig. 56, in which the large end in all of the pieces is indicated by L E and the small end which goes into the large end is shown by S E. Or, as better shown by Fig. 57, which being a section, shows how pieces are lapped for riveting. It makes no difference how many pieces the elbow may have, the principles will be similar to those given in the four-pieced elbow in Fig. 58.

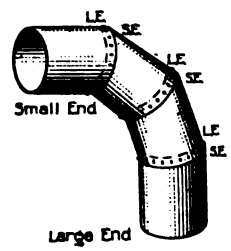

Fig. 56. Perspective

First draw the side elevation of the elbow desired, in this case four-pieced, as shown by *s t u v*, and from the corners E, F and G draw miter lines to D. Add the straight pieces of pipe as shown by A D and B C, making them equal to the outside diameter of the normal profile of the pipe. In other words, if the inside diameter of the normal or given profile of the pipe is 20 in. and the elbow is to be made of metal 3-16 in. thick, then the distances B C and A D will be made 20⅜ in. Knowing the outside diameter of the normal pipe, complete the side elevation of the elbow. Number the pieces I, II, III and IV. Directly below the line B C draw the normal profile of the pipe, struck from the center *m*. The thickness of the metal is shown by X. Assuming that the pieces are to fit into one another as shown in Fig. 57, or by the direction of the arrow H in Fig. 58, then the large ends would be at the lower ends of the pieces I, II, III and IV and the small ends at the upper ends of similar pieces I, II, III and IV.

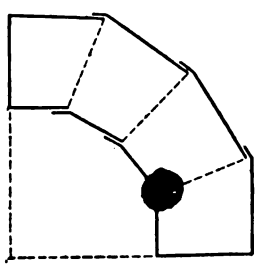
Fig. 57. Method of Joining

Divide the outer curve, representing the outer diameter of the pipe, into equal parts, as shown from 1 to 5, in the semicircle in the normal profile, and take twice the girth from 1 to 5 and place it on the horizontal line K as shown from 1 to 5 to 1^v. From 1^v set off the distance 1^v *a* equal to 7 times the thickness of the metal in use. Using 1 as a center and 1 *a* as radius, describe the arc *a* 1°, which intersect by a perpendicular line erected from 1^v at 1°. Draw a line from 1° to 1, and from the various divisions 2 to 5 to 2 on the line J K erect perpendiculars until they intersect the slant line 1° 1, at 2° to 5° to 2°. This length 1° 1 is then the true girth for the wide end of the pipe; in other words, when this girth 1° 1 is rolled up, the normal profile shown below the elevation will fit inside of same.

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To obtain the girth of the small end of the pipe, which will give the true inside diameter as called for in the normal profile, take 3½ times the thickness of

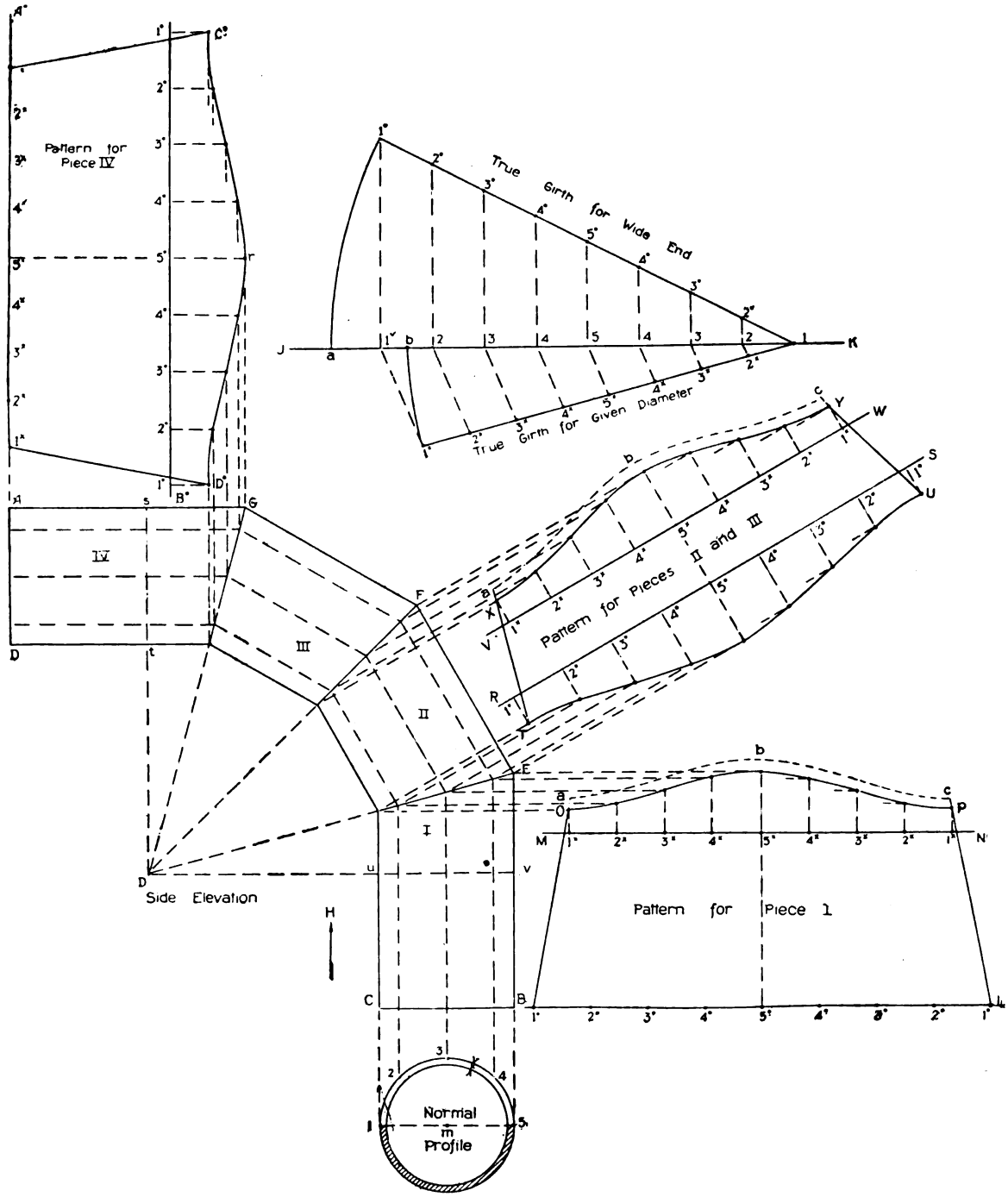

Fig. 58. Details of Pattern for Pieced Elbow Made From Heavy Metal

the metal and deduct it from the length 1ᵛ 1 on J K as shown from 1ᵛ to *b*. Then using 1 as center and 1 *b* as radius, draw an arc of any desired length, as *b*

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1^x, and draw a line from 1^x to 1. Draw a line from 1^v to 1^x and parallel to this line from the divisions 2 to 5 to 2, draw lines until they intersect the line 1^x 1, from 2^x to 5^x to 2^x. Then will the length 1^x 1 represent the true girth for the small or given diameter of the pipe, which, when rolled up, will correspond to the normal profile. In practice it is only necessary to find the one division 1°, 2° on the wide end and the one division 1^x, 2^x on the small end, as the other respective divisions are equal.

The true girths having been obtained, the patterns are now in order. The taper in the patterns is greatly exaggerated to make the various operations clear and distinct. To obtain the pattern for piece I, take the girth of the wide end from 1° to 5° to 1 and place it on the line C B extended as B L, as shown by similar numbers 1° to 5° to 1°. At right angles to E B, at any point between E and B draw the line M N, which intersect at 5^x by a line erected from the center point 5° at right angles to B L. Take the half girth 5^x to 1^x of the small or given diameter, and place it on the line M N, on either side of the center line 5° 5^x, as shown by the divisions from 5^x to 1^x. At right angles to M N, through the small figures on same, erect vertical lines, which intersect by lines drawn parallel to M N, from similar numbered intersections on the miter line E D. Trace a line through points thus obtained as shown by O P, and draw lines from O to B and from P L. Then O P L B will be the pattern for piece number I.

To obtain the pattern for pieces II and III, draw any two lines at right angles to E F, as shown by V W and R S. On the lower line R S place the girth of the wide end as shown from 1° to 5° to 1°, and through 5° at right angles to R S erect a line intersecting V W at 5^x. On either side of 5^x place the semigirth 5^x 1^x equal to the semigirth 5^x 1^x of the given diameter or small end of the pipe. At right angles to R S from the various divisions 1° to 1°, draw lines which intersect by lines drawn parallel to R S from similar numbered intersections on the miter line E D. Trace a line through points thus obtained as shown from T to U. In a similar manner at right angles to V W, from the intersections 1^x to 1^x erect lines, which intersect by lines drawn parallel to V W from similar intersections on the miter line F D. Trace a line through these intersections as shown from X to Y and draw a line from X to T and from U to Y. X Y U T will be the pattern for pieces II and III.

In this connection it may be proper to remark that if the elbow were made of 10 pieces which would have 8 middle pieces, then the pattern obtained for the first middle piece, as II in this case, would answer for all 8 in the 10-pieced elbow, in the same manner as the pattern for II in this case also answers for III, because the miter joints lap the same as shown in Fig. 56.

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For the pattern for piece IV in Fig. 58, extend the line D A as A A°, on which place the girth of the small end of the pipe, as shown from 1^x to 5^x to 1^x. From the center 1^x at right angles to A A° draw the line 5^x *r*, which intersect at 5° by the line B° J drawn at right angles to A G at any desired point, between A and G. Take the semigirth of the wide end from 5° to 1° and place it on either side of 5° on the line B° J, as shown from 5° to 1°. Through these small figures at right angles to J B° draw lines, which intersect by lines drawn parallel to J B° from similar numbered intersections on the miter line G D. Trace a line through points thus obtained as shown from C° to *r* to D°, and draw lines from D° to 1^x and from C° to 1^x. Then will 1^x C° *r* D° 1^x be the pattern for piece IV.

A lap must be allowed along the seam for riveting, also a lap for riveting along the miter joint as indicated by *a b c* in the patterns. The laps along the miter joints must be flanged to the proper angle.

PATTERN FOR A Y OBLONG TO ROUND

To describe the pattern for the Y shown in Fig. 59, the first step is to construct a section on H E. As the width through the point H is equal to I K in plan, or A B in elevation, and the hight to H E, draw at pleasure the shaded section A E B.

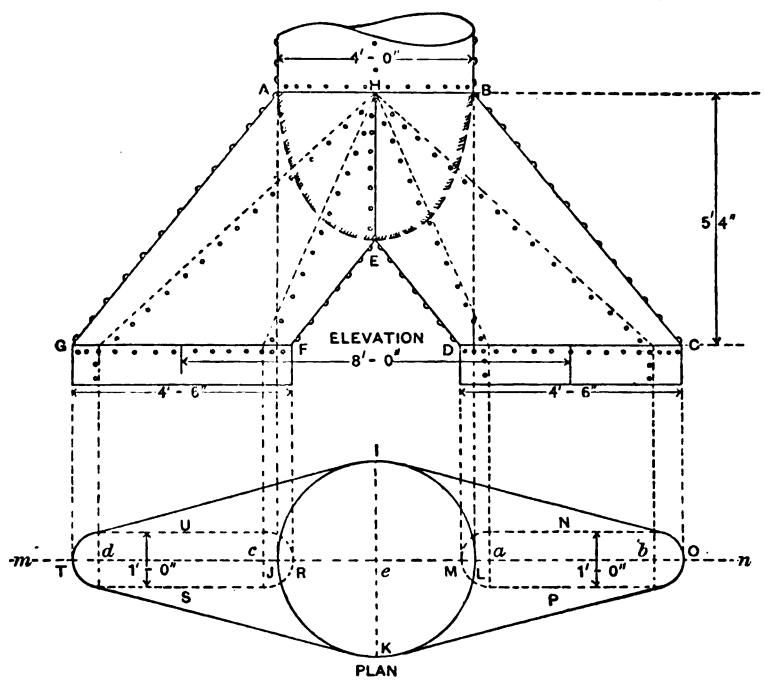

Fig. 59. Plan, Elevation and Section on H E

Take a tracing of H B C D E, and place it as shown by 10′ 1 2 7 8 in Fig. 60; a tracing of A H E in Fig. 59, and place it as shown by 10 10′ 8 in Fig. 60, and a tracing of the quarter section I *e* L in plan in Fig. 59, and the half section M P O, and place them in Fig. 60, as shown by 10″ 10′ 1 and 7 5 4 2 respectively. Divide the quarter circles in *a* each into two equal parts, as shown by 2, 3, 4, 5, 6 and 7. Also divide the two sections *c* and *b* into two equal parts, as shown

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by 8, 9 and 10, and 10″, 11, 1. In practice more space should be employed. At right angles to 2 7, 8 10′ and 10′ 1, and from the various points just obtained in the profiles *a*, *c* and *b*, draw lines to their respective base lines. Connect opposite points, 1 to 3′ to 11′ to 4′ to 10′ to 5′ to 9′ to 6′ to 8. Then will these lines represent the bases of sections which will be constructed, the altitudes, or hights, of which are

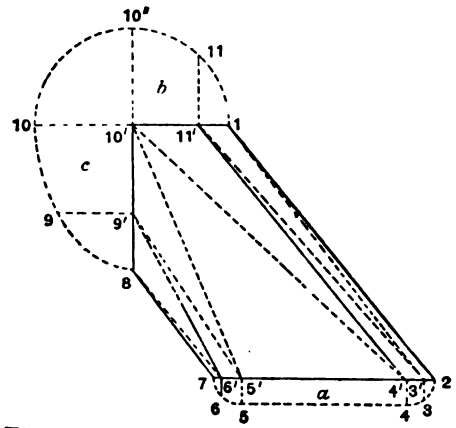

Fig. 60. Obtaining Measurements for Sections

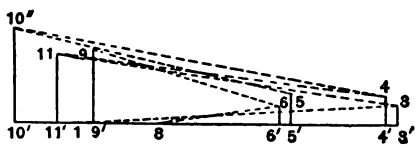

Fig. 61. Diagram of Sections

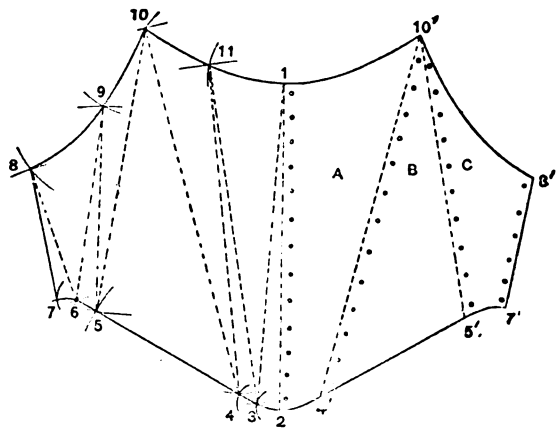

Fig. 62. The Pattern Shape

equal to similar numbers in the sections *a*, *b* and *c*, as indicated in Fig. 60.

In Fig. 61 is shown the method and diagram for obtaining the true lengths of the dotted lines in 1 2 7 8 10′ in Fig. 60.

For the pattern draw 1 2 in Fig. 62, equal to 1 2 in Fig. 59. Now using 2 as center and 2 3 in *a* in Fig. 60 as radius, describe the arc 3 in Fig. 62, which intersect by an arc struck from 1 as center and 1 3 in Fig. 61 as radius. Then with 1 11 in *b* in Fig. 60 as radius and 1 in Fig. 62 as center describe the arc 11, which intersect by an arc struck from 3 as center and with 3 11 in Fig. 61 as radius. Proceed in this usual manner until the line 7 8 in Fig. 62 is obtained. Trace a line through points thus found. Then will 1 10 8 7 2 be the half pattern.

If the Y were smaller and a pattern is desired in one piece, trace the half pattern opposite. As the Y in this case is of such large dimensions and is to be made from No. 10 steel, each branch had better be made in six parts, three of which are shown punched for riveting at A, B and C in Fig. 62. If a lap joint is required the laps must be added to the dividing lines in the pattern, or if butt joints are wanted it will be necessary to punch on either side of the lines in pattern. The elevation in Fig. 59 shows the joints riveted, using a lap joint. Laps must be allowed to the top and bottom of the pattern to allow the stack and neck collars to be riveted to same, as shown in Fig. 59.

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ADJUSTABLE SLEEVES FOR STEAM PIPES

In buildings that are constructed in conformity with the requirements of the fire underwriters and the fire protection regulations of large cities, it is necessary to protect the material of the various floors through which the large steam mains and returns pass in going to the various radiators supplied. Steam fitters who engage in such work, whether the floors are composed of terra cotta and concrete supported by iron beams or wooden joists and floor covering, are accustomed to inclose the steam pipes in a sheet metal casing. These sleeves are so arranged that they are adjustable to different thicknesses of floors and allow free expansion and contraction of the steam pipes.

The method of construction is shown in the accompanying illustration, Fig. 63, although the methods of different shops vary. The sections consist of two parts, the upper section being shown at the left and the bottom section at the right, while the two sections connected are shown in the center. The sections consist of a sheet iron cylinder or rectangular tube, either double seamed or riveted together, of suitable dimensions to inclose the pipes in connection with which they are used. In some shops, after cutting the two holes in the top piece and the bottom piece for the pipes to pass through, little angle formed lugs are riveted to the sleeve proper, and these, in turn, are riveted to the top and bottom piece, forming practically two boxes open at one end. In addition to the holes for the pipes two small holes are provided for the connecting rods, which are threaded at both ends for nuts. The two sections are made of slightly different size, so that one can readily slip into the other. When the steam fitter is running his risers he puts on a top piece and a bottom piece at each floor. The top piece naturally rests on the floor by gravity, while the bottom piece must be held by one workman while another workman assists in making the connection between the two parts and screwing up the rods which hold them securely in place. Steam fitters doing a large business, in the majority of cases have a sheet metal working shop for the making of ducts, fan systems and the like, work that is coincident to a steam fitting business; manufacture their own sleeves, although there are sleeves in the market that can be purchased for this purpose.

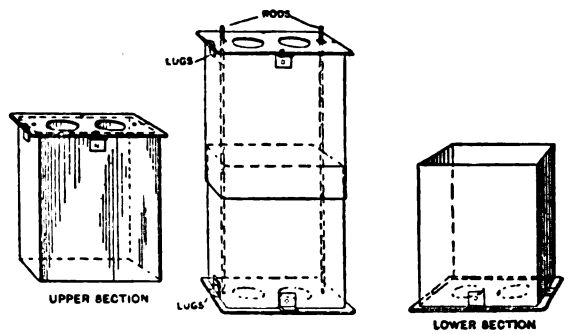

Fig. 63. Adjustable Sleeves for Steam Pipes

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PATTERNS FOR ELBOWS MITERING WITH ROUND PIPE

In this article it will be shown how to obtain the patterns for the Y shown in Fig. 64, which is formed by means of an elbow springing from a vertical pipe, and also for the T shown in Fig. 65, formed by means of two elbows joining together as shown. In the former case the vertical pipe is 18 in. in diameter, and the diameter of the elbow 12 in. In the latter case both elbows and pipe are 18 in. in diameter. The problem shown in Fig. 64 will be worked out in detail, showing how the principles can also be applied to Fig. 65. It is immaterial what diameter the pipe or elbow may have, or how many pieces are contained in the elbow, or what radius is used in striking the throat of the elbow, the principles hereinafter given are applicable to any case.

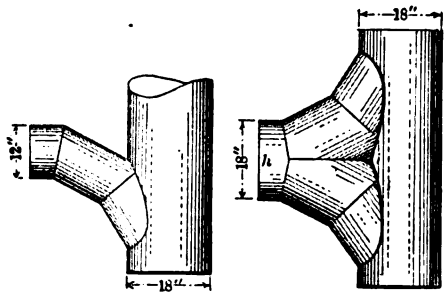

Fig. 64. Single Elbow Fig. 65. Double Elbow

In Fig. 66 draw any horizontal line as A B and with any point on this line as A, describe the elbow shown by C D E F G H J K L M. In its proper posi-

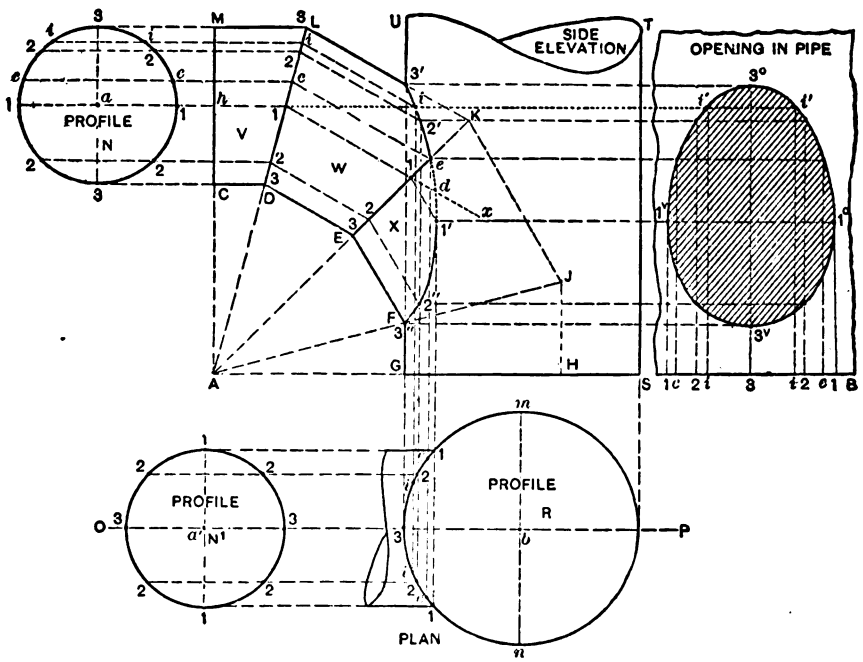

Fig. 66. Plan, Elevation, Profiles and Pattern

tion draw the profile through M C of the elbow as shown by N, struck from the center a; and in its proper position below the elevation G S T U of the pipe draw the profile through G S of the pipe, as shown by R, struck from the center

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b. Through the center *a* in the profile N draw the two diameters as shown, and divide the circle into equal spaces, in this case but eight, as shown, from 1 to 3 to 1, etc.

Through the center *b* in the profile R draw the line O P, upon which locate at pleasure the center point a^1, which use as center to describe the profile N^1, similar in size and divisions to the profile N. Notice that if points 1 and 1 are at the sides in profile N in elevation, they will be at top and bottom in profile N^1 in the plan, which represents the sides when viewed from the top. Now through the various intersections 1 to 3 in the profile N^1 in plan draw lines parallel to O P until they cut the profile of the main pipe R, as shown from 1 to 3 to 1. In similar manner, through the various points of intersections 1 to 3 in the profile N in elevation, draw lines parallel to M L, until they cut the miter line L D of the elbow, as shown from 3 to 1; from these intersections on L D, parallel to L K, draw lines until they cut the miter line K E, from which points, parallel to K J, draw lines indefinitely, as shown, and intersect these lines by lines drawn parallel to G U of the pipe, from similar intersections in the profile R, thus obtaining the points of intersections 3′, 2′, 1′, 2″ and 3″. Trace a line from 3′ to 2′ and from 1′ to 3″.

Before a line can be traced from 2′ to 1′ it is necessary to know where the miter line between the elbow and main pipe will cross the miter line K E of the pieced elbow, and is obtained as follows: Assume that the cylindrical portion W of the pipe intersects the main pipe. Therefore extend the required line following 2′, which is 1 as from 1 to *x* and intersect it by a vertical line erected from 1 in the profile R locating point *d*. Extend the miter line 3′ 2′ to *d*, as shown, and where this curved line crosses the miter line K E is the desired point, or *e*. From *e* complete the miter line *e*, 1′, 2″, 3″, and it will be found that this line will pass over the one previously drawn to *d*, owing to the small size of the drawing, which however, will not be the case when drawn full size. From the intersection *e* drop a vertical line, until it meets the profile R at *e* and *e*. In similar manner from the intersection *e* on the miter line K E draw a line parallel to K L until it meets the miter line L D at *e*, from which point, parallel to L M, draw a line intersecting the profile N at *e* and *e*. Then will the miter line from 3′ to *e* to 3″ in elevation represent the intersection between the elbow and main pipe. All that part of the elbow shown by dotted lines K J and H will not be required.

The development of the patterns is now in order. To obtain the opening to be cut in the main pipe take the girth of the various spaces contained in the profile R of the main pipe, as shown from the horizontal line S B. From these points at right angles to S B erect vertical lines, which intersect by horizontal lines drawn from

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similar numbered and lettered points in the miter line 3′ *e* 3″ in elevation. A line through 3° 1ᵛ 3ᵛ 1°, gives the opening in the main pipe, shown shaded.

To obtain the patterns for the pieces V, W and X, a tracing of these pieces, with the various points of intersections, has been transferred to Fig. 67, as shown by similar letters and figures. Now, to obtain the pattern for V, extend the line C M, as shown by M A, upon which place the girth of the profile N. From these points at right angles to M A draw lines, as shown, which intersect by lines drawn parallel to M A from similar numbered intersections on the miter line between the pieces V and W, then will A B D 3 be the pattern for piece V.

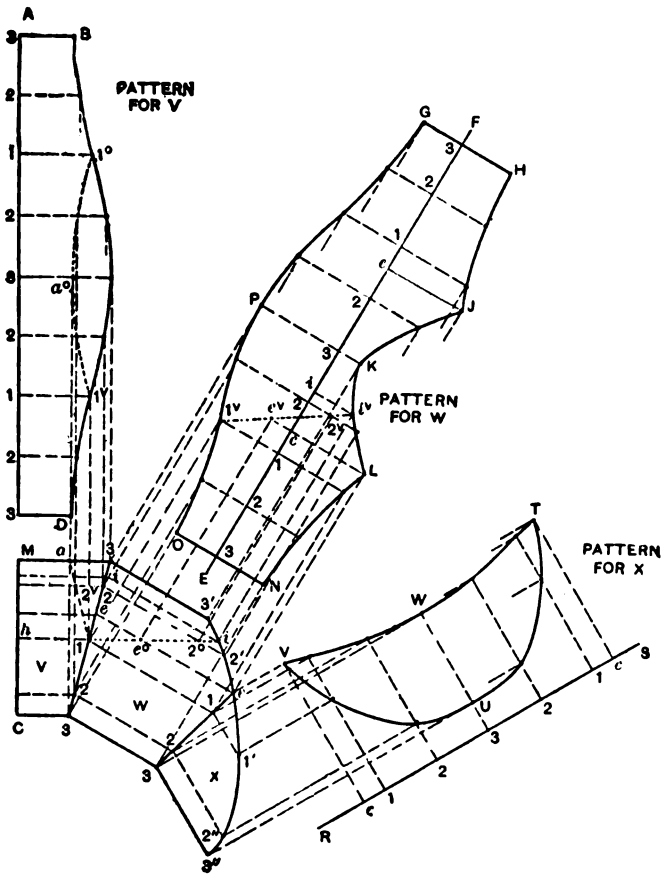

Fig. 67. Developing Pieces in the Elbow

The pattern for piece W is obtained by drawing the girth line E F at right angles to 3, 3 in W, and placing on this the girth of the profile N in Fig. 66, being careful to include the intersections *e* between 1 and 2, as shown by similar letters and figures on E F in Fig. 67. Through these points at right angles to E F draw lines indefinitely, which intersect by lines drawn parallel to E F from similar lettered and numbered points of intersections on the miter line 3, 3 on the left of W and the miter line 3′ *e* 3 on the right. When a line is traced through points thus obtained, as shown by G P O on the left, and N L K J H on the right, the desired pattern with seam in throat will be obtained.

For the pattern for X, draw the line R S at right angles to 3 3″, upon which place only the girth of the lower part of the profile N in Fig. 66, from *e* to 3 to *e* (as only that much of the profile miters with the main pipe in elevation from *e* to 3″). Proceed as before, T U V W T being the pattern desired.

If desired these patterns can be proved thus: Measure the various intersections in opening in pipe in Fig. 66 from 3ᵛ to 1° or 3ᵛ to 1ᵛ, and compare them with the

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various spaces in pattern for X in Fig. 67 from U to T or U to V respectively. In similar manner the various spaces in pattern for opening in Fig. 66 from 1° to 3° to 1^v are compared to similar intersections in pattern for W in Fig. 67 from J to K to L respectively. This, then, completes the patterns for a single elbow mitering on a pipe similar to that shown in Fig. 64; laps or edges of course, to be allowed for riveting or seaming.

The second case shown in Fig. 65, shows a double elbow mitering on a pipe, in which both diameters of the pipe and elbow are equal. To show this problem would require another set of drawings, and to avoid this, as the principles are similar, assume that the double elbow is to be 12 in. in diameter, thus allowing the drawings and patterns already described to be used in developing the patterns for an elbow similar to Fig. 65, excepting the change in diameters. While the elbow in Fig. 66 intersects the main pipe in plan as far as 1 1, if this elbow were of the same diameter as the main pipe, it would intersect the main pipe at *m* and *n*, the principles in all the operations, however, being similar, as before explained.

All that would be necessary, if a double elbow were to intersect the main pipe in Fig. 66, is to draw a horizontal or miter line from the center *a* in the profile N until it cuts through the elevation of the elbow, as shown by *h i*. This line *h i* then represents the joint line between the two elbows, as indicated by *h i* in Fig. 65. In its proper position draw the line *h i* in Fig. 67, crossing the lines *e* and 2 in piece W at *e*° and 2°. Now take a tracing of *h i* 3″ C in Fig. 66 and double it on the line *h i*, as shown by similar letters and figures in Fig. 68, thus showing the appearance of the double elbows from dimensions obtained from Fig. 66. Thus it will be seen that the pattern for X in Fig. 67 remains the same for X^1 in Fig. 68, but a change of pattern will be required for W^1, because they miter along *h i*, and is obtained as follows:

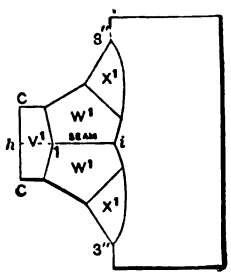

Fig. 68. Elbow Doubled From Fig. 66

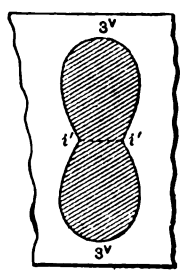

Fig. 69. Opening for Double Elbow

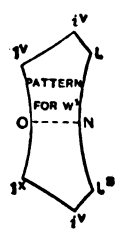

Fig. 70. Pattern for W1, Fig. 68

From the intersection *i* in elevation in Fig. 66 drop a vertical line in the plan cutting the profile R at *i* and *i*. Take the distance from 2 to *i* on both sides in profile R and place it on the girth line S B, also shown from 2 to *i* on both sides, and from the points *i* erect vertical lines, which intersect by a horizontal line drawn from point *i* in elevation, thus obtaining points i^1 i^1 in the pattern. Take a tracing of i^1 3^v i^1 and place it as shown in Fig. 69, by i^1 3^v i^1, tracing it on either side of

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the line i^1 i^1. This represents the pattern for the opening to be cut in the main pipe, to receive the double elbow shown in Fig. 68.

Again referring to Fig. 66, from the intersection i in elevation draw a line parallel to the piece W until it intersects the miter line L D at i. From this point draw a horizontal line, cutting the profile N also at i and i. Take the distance from 2 to i in profile N on either side and place it on one side of the girth line E F in Fig. 67, as shown, from 2 to i between 2 and 3. From i draw a line perpendicular to E F, as shown, which intersect by a line drawn parallel to E F from the intersection i on the miter line 3′ e. In similar manner from the intersections 2° and e° draw lines parallel to E F, intersecting the lines 2 and e in the pattern at 2^v and e^v, respectively. Draw the miter cut as shown dotted from 1^v to i^v. Then will 1^v O N L i^v be the half pattern; for the full pattern trace this half opposite the line O N, as in Fig. 70, which represents the pattern for the pieces marked W^1 in Fig. 68 with a seam along 1 i.

To obtain the full pattern for V^1, simply draw a line from 1 to a in V in Fig. 67, crossing line 2 at 2^v, and project points into the pattern for V, as shown. Then will A B 1° a° 1^v D 3 be the pattern for V^1 in Fig. 68. Laps and edges must be allowed on these patterns for seaming purposes.

OBVIATING NOISES IN FAN SYSTEMS

A complaint often heard in reference to a heating or ventilating system which depends upon a blower or suction fan to keep the air in motion is that the sound of the vibration of the fan is transmitted so plainly by the metal ducts and flues that it becomes an annoyance. A good way to avoid this is to put in a canvas joint where the fan collar connects to the duct. To make the connection the metal duct should not start at the collar of the fan, but a gap of several inches should be left, which gap should be filled in by means of the canvas joint.

In making the connection to the fan consider that the collar is rectangular or square and take a strip of galvanized iron long enough to go around the collar and wide enough to fold up into the canvas. The first step will be to form the metal as shown by Fig. 71. Slip the canvas into the fold of the metal as far as it will go and clinch it down in the folder or brake, or close it down with a mallet. The next operation is shown in Fig. 72, which is merely turning the galvanized iron over in the brake and mashing it down. When holes are punched through this to correspond with the holes in the collar of the fan, this end of the expansion joint

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is ready to be attached to the collar of the fan, which is done by bolting it as shown in Figs. 75 and 76. By this method the canvas is folded into the galvanized iron in such a way that it cannot get out. Both edges of the galvanized iron should be hemmed before the strip is bent, so there will be no sharp edges to cut the canvas.

The end of the canvas joint that joins the duct should have a piece of galvanized iron folded over it somewhat similar to the end next to the fan, and this should be turned up and clinched up over an edge turned out square on the top, bottom and both sides of the duct. The first step in preparing this end of the joint is to hem one edge of the galvanized iron and fold it over the canvas, as shown in Fig. 73, and close the edge down tight. Fold this over and close it down tight, as shown in Fig. 74. Next turn 1 in. up square and 1 in. out square, as shown by dotted lines in Fig. 74. Then turn 1 in. out square all around on the metal duct, bolt the canvas joint to the collar of the fan, sew the canvas where it laps on the longitudinal joint, slip the edge shown by the dotted lines in Fig. 74 over the edge turned out on the duct; turn it down, hammer it tight and put a few rivets or bolts through to make sure the joint will not come apart. This makes a practically airtight joint and one which will allow the air to flow freely, but which will transmit none of the vibration to the ducts. The joint in section would appear as in Fig. 75.

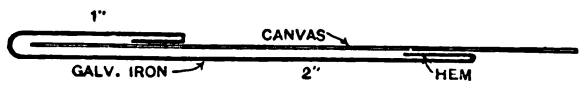

Fig. 71

Fig. 72

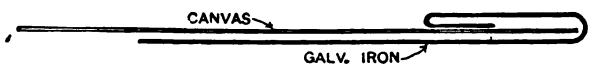

Fig. 73

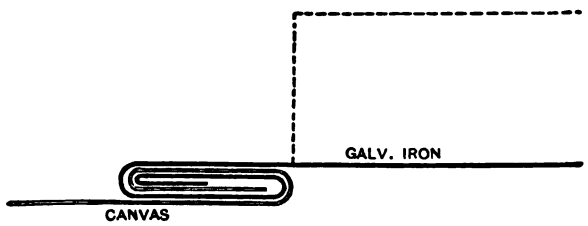

Fig. 74
Method of Joining the Canvas and Metal

If the collar of the fan happens to be round, the galvanized iron can be folded on the canvas at the side which will fit on the collar of the fan, and the galvanized iron folded on the side of the canvas that fits onto the circular duct the same as shown in Fig. 74, before the edges shown by the dotted lines are turned. This would leave that edge of the galvanized iron flat, as shown by the solid lines in Fig. 74. The canvas strip, with the metal binders clinched to each side, would then be formed up in the rollers to fit the collar of the fan and the end of the metal duct, and would be bolted to the collar of the fan the same as in Fig. 75, but the side next to the duct would lap over same and be soldered and riveted instead of having an

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edge turned up and over as it would in the case of the square or rectangular duct. The joints for the circular duct would then be as shown by Fig. 76.

The longitudinal joint in the canvas would be sewed. Care should be taken with these joints, especially for round collars, to allow for the thickness of the material, as this will be considerable, as there are four thicknesses of galvanized iron and two of canvas, which will aggregate from ⅛ to ¼ in. in thickness, which means from ¼ to ½ in. added to the diameter of the fan collar, or ⅞ to 1¾ in. to the circumference.

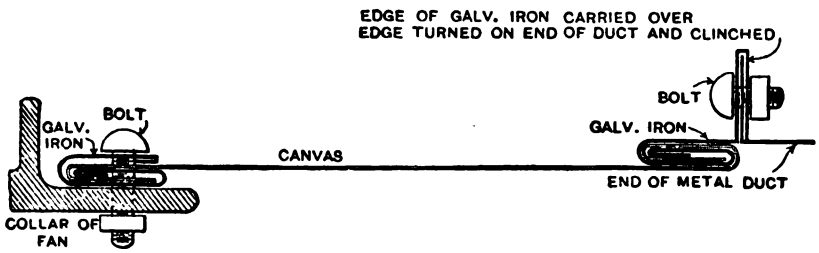


Fig. 75

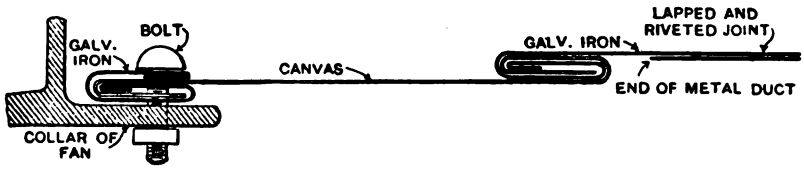


Fig. 76
Sections Showing Canvas Connections

Fig. 77 shows another construction of a flexible joint for a circular pipe. The ends are located 4 to 6 in. apart and connected by the canvas sleeve which is slipped over the bead on the pipe, doubled under at the ends and secured in place by annealed galvanized wire drawn up tight.

For rectangular pipes the method shown in Figs. 78 and 79 may be used. The canvas is doubled under as before and held in place by stove bolts passing through

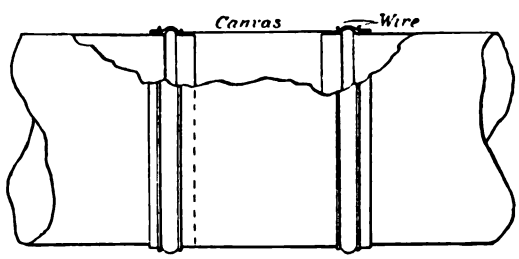
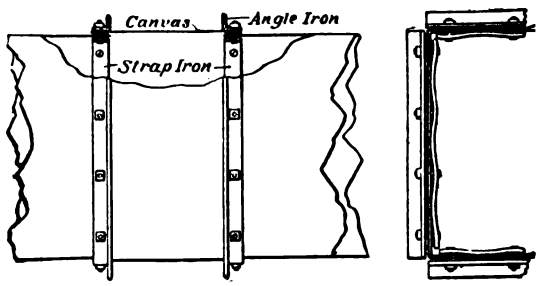


Fig. 77. Flexible Joint for Round Pipe



Figs. 78 and 79. Joint for Rectangular Pipe

the angle iron, canvas, galvanized iron and the strap iron inside the duct. The holes should be punched about 4 in. on centers, and before putting the strap iron in place in the inside of the duct, it should be placed on supports, the same distance on centers as the holes, and slightly bent as in Fig. 79, so that when drawn up in place by the bolts, the spring in the iron will force the galvanized iron hard against the canvas between it and the angle iron, making a tight joint. Canvas joints of

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this description should be thoroughly painted after they are put in place, to prevent the leakage of air.

CONSTRUCTING A RECTANGULAR DUCT

In Fig. 80 is presented a sketch, which shows a plan view of a duct, A, 30× 80 inches in size at its largest section and 31 feet long, having five branches or outlets of the size as indicated. A section taken through B C would appear as shown by D, which makes the depth of the duct 30 inches and the side view of the branch 20 inches, as shown in plan. Then, in this case, the connections between the branches and duct should take place on the lines X, X, X, etc., the side of the branch appearing as shown by J E F H in section D, connecting the 20-inch opening of the branch to the 30-inch opening of the duct by means of the curved corners, as shown.

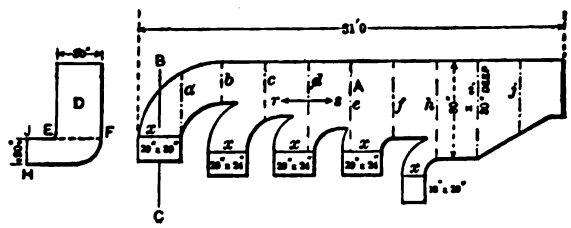

Fig. 80. Plan of the Duct to be Made

In constructing a large duct of this kind, where a number of sheets are to be joined together, a rigid construction must be provided for. While there are various methods employed, the one shown in Figs. 81 and 82 is usually adopted, as it prevents sagging in the middle. Assuming that iron 36 inches wide will be used, the duct will require a little more than ten widths, as shown by *a b c d e f h i j* in Fig. 80. All the corners on the entire duct should be double seamed, as shown by A and B in Fig. 81. In A is shown the single edge turned up on top and bottom, while on the 30-inch depth of the duct is added the double edge, as shown, which is closed, using the "dolly and mallet," as at B. At C is shown the standing seam taken through *r s* in Fig. 80 and riveted at intervals, as at *a* in diagram C in Fig. 81. This standing lock should be made about 1 inch high, notching out at the ends where the doubled lock B takes place, as shown at *b*, and turning over a lap on the ends, as at *c*.

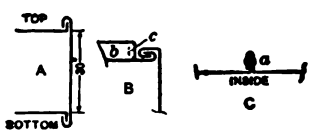

Fig. 81. Method of Locking Seams

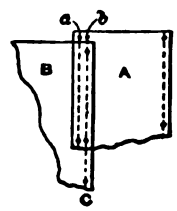

Fig. 82. Method of Laying Out Sheets

When laying out a large duct of this kind the floor is swept clean, a rough diagram made with chalk upon the same and the sheets dotted, as shown in Fig. 82, in which A is a sheet having a single and double edge and B a sheet having a single edge. The sheets are now laid one over another, so that the line *c* on the

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sheet B meets the second line *b* on the sheet A, as shown. Of course the sheets should be made even at the ends, B being shown lower to indicate the method of lapping. When all the sheets are laid out to the required length of 31 feet, tack the sheets to the floor with roofing nails and draw out the full sized duct, allowing for and notching the laps for double seaming. The sheets must then be marked and bent up on the brake, being careful to have all the numbers toward one side. The duct is then put together at the building, using band iron hangers to fasten against the ceiling or wall. It should be understood that the 30-inch depth of the duct is a plain strip with the necessary edges allowed, while the top and bottom have the standing seams.

GALVANIZED IRON WORK FOR FAN SYSTEMS

This article will treat of various methods commonly employed in the construction of ducts and flues used with the fan systems of heating and ventilation, and will take up details of dampers, hangers, etc. Tables of the weights of round

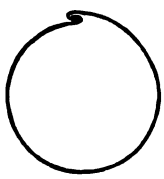

Fig. 83.

Fig. 84.

Longitudinal Seams

Fig. 85.

and rectangular pipes will be given, together with extracts from specifications dealing with gauges and methods of construction. Although such work is used chiefly with fan systems the following will apply equally well to large gravity systems:

Longitudinal seams in round or oval pipes are generally made with the usual lock edges, as shown in Fig. 83, on all gauges up to and including No. 20 iron. After the edges are locked the pipe is placed on a mandrel and the seam is set down with a hand groover of the proper size and is then set down flat with a hardwood mallet, making a finished seam, as shown in Fig. 84. The cost of these operations can be materially reduced if one of the various styles of hand or power machine groovers now on the market is used. Pipe jointed in this manner meets all the requirements of a first class job and does not need additional soldering.

Piping of No. 18 and heavier gauges should be made with riveted lap joints. Rivets should be spaced about 2 or 2½ in. on centers, and buttoned down on surface of metal with a rivetset of proper size. The total lap should never be less than 1 in., as shown in Fig. 85.

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Figs. 86 and 87 show two methods of making joints in round or oval piping, and can be either soldered or riveted, as desired. Fig. 86 shows a single bead on

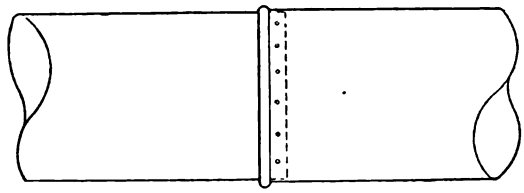

Fig. 86.

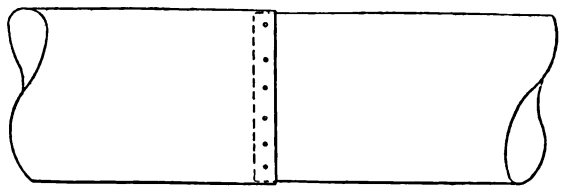

Fig. 88.

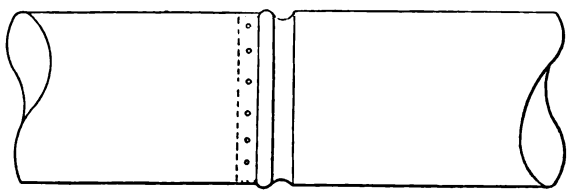

Fig. 87.

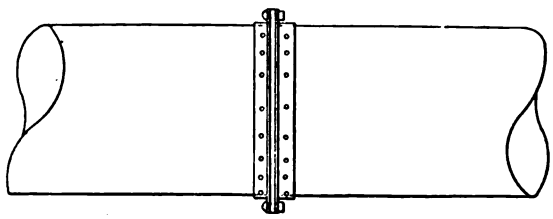

Fig. 89.

Joining Round Pipes

the small end of the joint, which is made to fit snugly in the large end of adjoining joint of pipe. Fig. 87 shows a bead on the small end of joint fitted to the large end of the adjoining joint. These beads serve to stiffen the pipe, and sometimes several are used close together for this purpose.

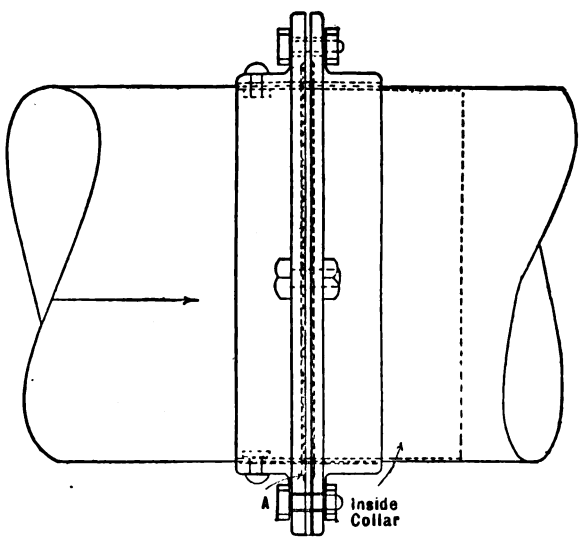

Fig. 90. Special Coupling Flange

Fig. 88 shows a plain lap joint, having a lap of about 2 in., and can be either soldered or riveted, or both, as required. Joints are marked out, allowing for an outside diameter on small end of joint and inside diameter on the large end of joint. When the proper allowance is made the small end should make a tight joint with the adjacent one, when the lap allowed has been reached.

Fig. 89 shows a method of using either cast or wrought angle iron flanges in making up joints on piping of heavy gauges or piping run in a vertical position on the exterior of a building. Angle iron flanges are generally riveted on each end of a length of piping, about 12 or 14 ft., which has intermediate riveted lap joints.

Fig. 90 shows a special flanged connection used on work that must be absolutely tight. Special angle flanges are recessed at A to receive the ends of the pipe section, which are flanged over. A collar about 3 in. long, made of a straight

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piece of iron rolled to diameter of the flange, is riveted to the small end of the pipe and extends beyond the joint. Such joints are used on pressure work, but are not required for ordinary heating and ventilating systems.

Elbows should have the internal radius at least equal to the diameter of the pipe with which they connect. Even in the smaller sizes they should be made up

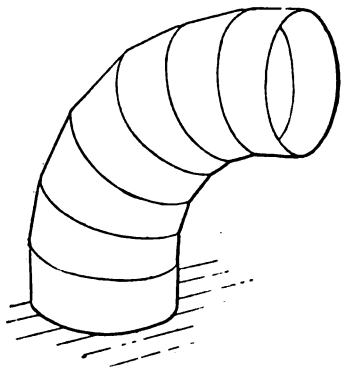

Fig. 91. Perspective of an Elbow

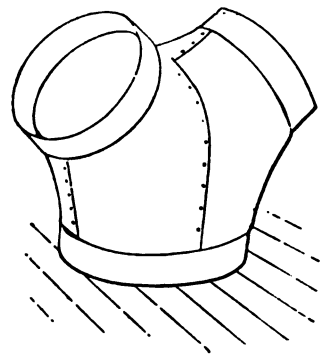

Fig. 92. Perspective of a Branch

of not less than five pieces, those above 8 in. usually having seven pieces. See Fig. 91. All elbows, except those of No. 18 gauge and heavier, are grooved and locked. Heavier elbows are riveted and soldered.

In blower work of good construction the branches are carefully designed somewhat as shown in Fig. 92.

Tapers to reduce from one size to another are generally made in a length of not over 36 in. They are either straight or offset to suit conditions.

Longitudinal seams on rectangular piping are made in various ways, and should be modified to meet the conditions of cutting sheets to make the various sizes of piping, also to suit the means of handling various sizes of piping in the shop.

Fig. 93 shows one of the most common ways of making a longitudinal seam. This is done by bending the single edge at right angles to the piping. The double edge is turned over and locked over the single edge, and the single and double edges are then bent over flat as shown.

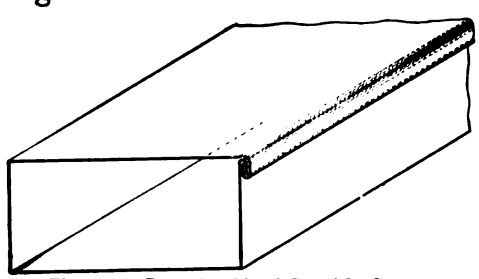

Fig. 93. Longitudinal Double Seam

Fig. 94 shows another method of making longitudinal seams, which is very popular in many shops; this is simply the ordinary grooved seam, and can be located at whatever point desired. This is an advantage, since the sheets can then be cut with a minimum of waste material. The seam is made in the manner described for round pipes. Where a hand or power machine groover is available, these joints can be made

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very quickly and at small cost, especially when piping is made up in 8′ 0″ joints. When large sizes of pipes are to be shipped to a distance, they can be made up in this manner, with seams left open during shipment to be put together by hand on the job. This facilitates handling, permits nesting during shipment and saves in the cost of transportation. Less damage is likely to occur during shipment than where the pipe is shipped made up. It is to be understood that the groove seam is often made the reverse of this; which is to say, on the inside of the pipe. This seam is made by pounding the lock into a groove in a suitable mandrel, familiar to all. Sheets can be taken from the bundle of iron, squared up in the shears and then taken to the cornice brake and edged on both sides, also making the right

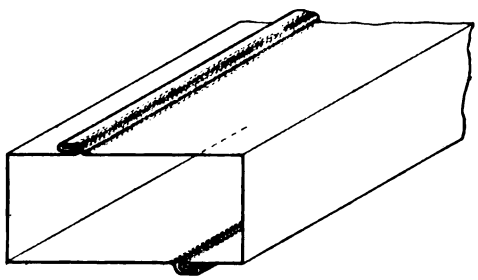

Fig. 94. Longitudinal Grooved Seam

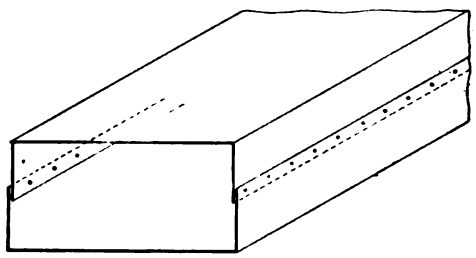

Fig. 95. Longitudinal Riveted Seam

angle bend all at one handling. This method can be used on all gauges up to and including No. 18, if the iron used is of a good grade. If poor iron is used it often cracks at the seam.

Fig. 95 shows the method of making longitudinal seams on piping of heavy gauges. They are ordinary lap seams and can be placed in almost any position.

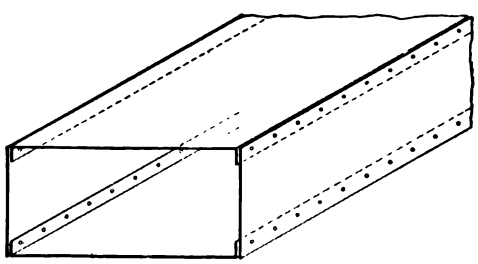

Fig. 96. Longitudinal Riveted Corner Seam

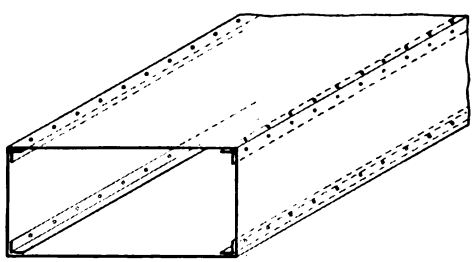

Fig. 97. Longitudinal Corner Seam With Angles

The lap on these seams should never be less than 1 in. and rivets spaced about 2 or 2½ in. on centers, and in about ½ in. from side of sheet, making rivet line in center of lap. When an especially neat job is required, regardless of expense, it is probably better to make the lap at the corners of the pipe, as shown in Fig. 96, and place the lap on the inside. The raw edge of metal can be rounded over the corner, making a very neat and serviceable job. Riveted joints should be made

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up very carefully and rivets buttoned down on the metal with a rivetset of the proper size.

Fig. 97 shows a general method of constructing ducts of heavy plate metal when metal is most too heavy to make a right angle bend on a sheet of ordinary length. Angle irons about $1\frac{1}{2} \times 1\frac{1}{2} \times 3\text{-}16$ in. are cut the exact length of sheets, and about 9-32 in. holes punched about 3 in. on centers.

Fig. 98 shows a method of making up joints for the lighter gauges of iron, say

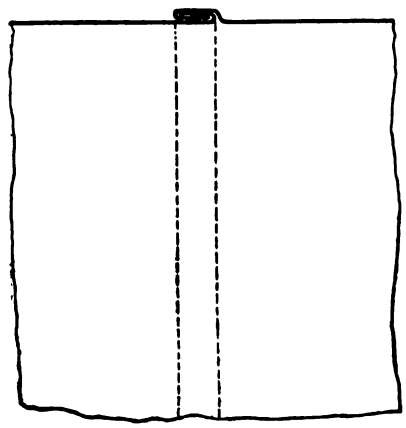

Fig. 98. Ordinary Cross Seam Joint

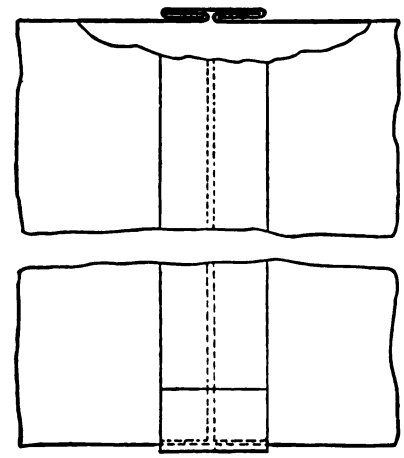

Fig. 99. Slide Joint by Means of a Slip

from No. 30 to No. 26, and is known as a double seamed joint. A single edge is turned up on one end of the joint of pipe, and a similar edge on the abutting end is slipped over it. Then both edges are brought over flat with a smooth mallet.

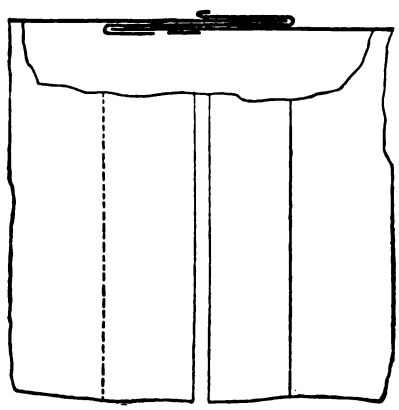

Fig. 100. Conventional Slip Joint

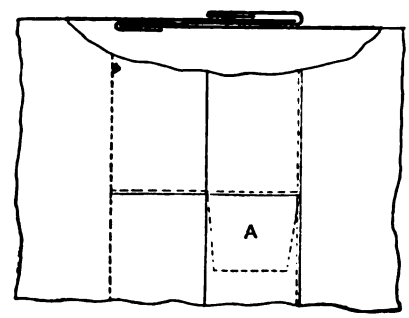

Fig. 101. Another Conventional Slip Joint

This seam should be dented by means of a good prick punch in order to avoid the joint slipping out while handling the finished length.

Fig. 99 shows a joint much used on good work and known as the slide joint. Edges are bent almost flat on the pipe, and a double edged flat piece is slipped

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over these edges. This makes a very neat and serviceable job, and has the advantage of being utilized in almost any tight corner, besides enabling the duct or casing to be taken apart for cleaning.

Fig. 100 shows a form of slip joint used where particularly neat work is required. The slip proper is made up separate from the piping, and outside edge wired with about 3-16 or ¼-in. round rod, then formed up with solid corners and riveted to small end of the duct, where provision has been made for its reception by cutting out the corner of the duct for the length of the slip. Then the large end of adjoining joint is placed into this slip as shown. Slips of this character should not have less than 2-in. lap, and outside section of slip should be about 1 in. wide.

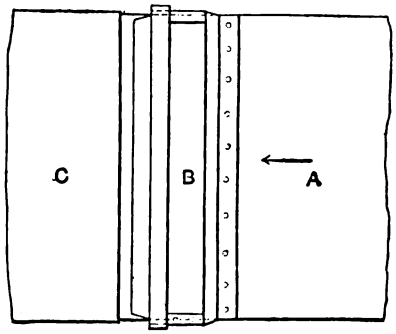

Fig. 102. A Simple Slip Joint

Fig. 101 shows the same pattern of slip joints as the foregoing, but without the wired outside edge, and in place of it a hem edge turned inside of slip, thus doing away with the raw edge of metal that would otherwise be exposed.

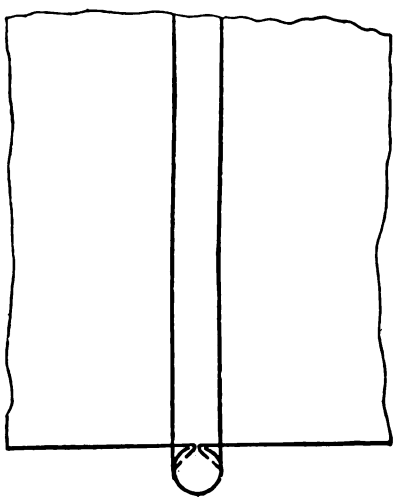
Fig. 103. Slip Joint for Neat Appearance

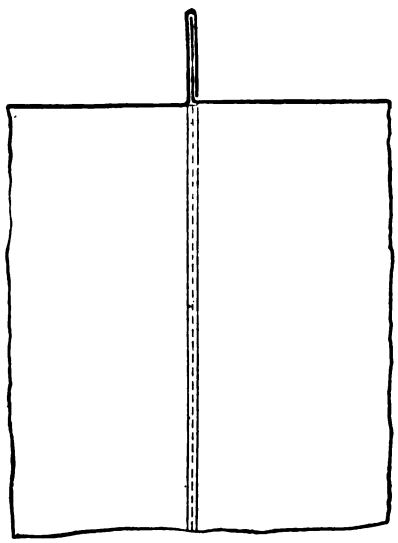
Fig. 104. Standing Seam Slip Joint

Fig. 102 shows a joint used by some blower manufacturers for their rectangular ducts. The sleeve B, into which the end of section C slips, is about 2 in. long. This joint gives the appearance of good workmanship in a system of ducts connected by this method.

Fig. 103 shows a method of making up joints, that has been used where a very neat job is desired. About ⅜-in. edges are bent up at an angle of 45 degrees on

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large and small ends of the piping. They are then placed together and a ½-in. brass tube previously slotted is slipped over the edges, mitering the corners of the tubing. This method of making joints is often used for cylinder lagging.

Figs. 104 and 105 show a joint used on large rectangular piping. This joint is practically a standing seam joint, makes a strong, firm joint and also serves to

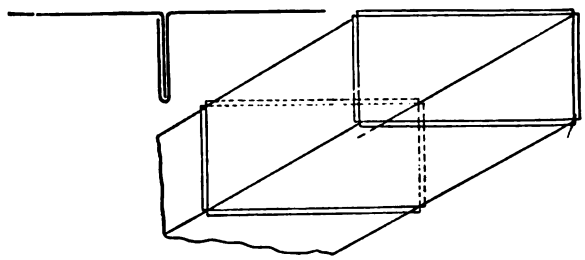

Fig. 105. General View of Standing Seam Joint

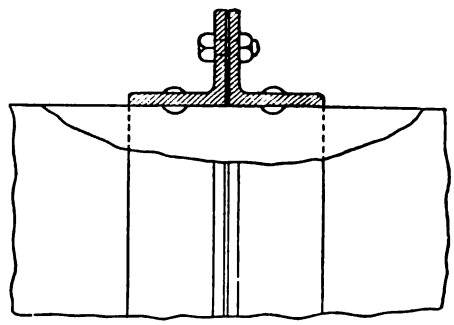

Fig. 106. Cross Joint by Means of Angle Irons

stiffen the piping. When these joints are made about 36 in. long they make a very rigid length of piping without the additional bracing generally necessary on piping of large sizes. The joint is made by bending a single edge about 1 in. at right angles to the side of the piping, and on the adjoining edge a double edge is bent, bending down nearly tight on three sides of the duct, allowing one side open in order to slip single edge into position. Then all sides are gone over and hammered down tight and riveted or bolted through the standing lock.

Fig. 106 shows angle irons arranged to make a joint between lengths of piping. The angles should be either 1, 1¼ or 1½ in., according to the size of the pipe. They should be riveted securely, making either a miter or butt joint on the corner of the piping.

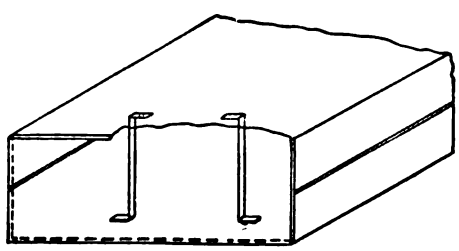

Fig. 107. Band Iron Braces

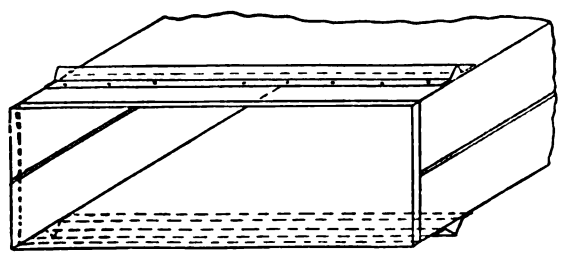

Fig. 108. Sheet Metal Braces

On rectangular ducts having a width of about 30 in. or over it is generally necessary to provide some means of bracing the wide sides of the ducts. Fig. 107 shows a popular and cheap method of bracing with bar iron braces, suitable to use on ducts up to 36 in. wide. Braces can be made of about 1¼ × 3-16 in. bar iron

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and bent up in Z form, as there is no tendency for the brace to turn sideways. Only one rivet is used on each end in riveting to duct.

Fig. 108 shows a method of bracing ducts by means of bent strips of about No. 18 iron, riveted to the ducts as shown.

Fig. 109 shows a duct braced with angle iron, which makes a thoroughly substantial job. Angle iron should not be less than $1 \times 1 \times \frac{1}{8}$ in. on ducts up to 40 in. wide, and using larger angle iron on sizes above this. Rivets should be spaced about 6 in. on centers and braces spaced about 32 in. apart.

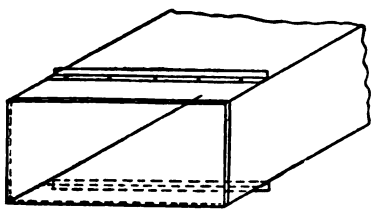

Fig. 109.
Angle Iron Braces

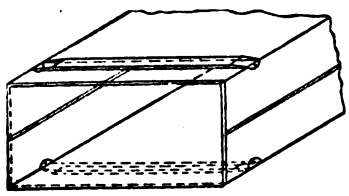

Fig. 110.
Incased Wood Braces

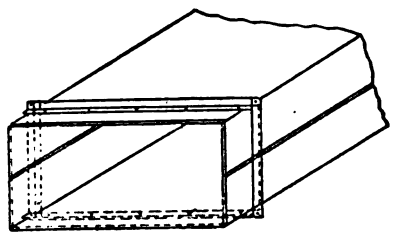

Fig. 111.
Complete Angle Iron Braces

Fig. 110 shows a method of using wooden strips incased in galvanized iron and fastened to the ducts by wire nails, clinched on the inside. Strips of hemlock or almost any soft wood, about $2\frac{1}{2} \times \frac{7}{8}$ in., with the ends tapered wedge shaped for a distance of about 4 in., are completely incased in a covering of about No. 26 galvanized iron, allowing a small tab for riveting to the side of the duct at each end of the brace. The rough edges of the iron are left on the under side of the brace, which is then set on the duct and 3-in. wire nails are driven through the brace and duct, then clinched over by the helper on the inside. This makes a cheap form of bracing, but is barred out by many specifications.

Fig. 111 shows a very good method of bracing rectangular ducts, and can be used on all sizes. Angle irons are cut for all sides, and an allowance equal to the width of the angle iron is made on each angle on each end. By setting angle irons on adjacent sides of the duct in an opposite position, you have angle irons meeting back to back at the corners, then having a hole in each, they can be bolted or riveted together, forming a complete frame around the duct. This feature is made use of in erecting them on a length of piping, as the necessary number of braces can be bolted around the piping, then all riveted to the piping at one time, thereby saving labor in handling. Angle irons should be $1 \times 1 \times \frac{1}{8}$ in. on smaller sizes of piping requiring bracing and $1\frac{1}{4} \times 1\frac{1}{4} \times 3\text{-}16$ in. on ducts of larger dimensions. Space rivets about 6 in. on centers and space braces about 32 in. on centers. Fig. 112 shows a method of joining corners of this brace in larger detail.

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Transformation pieces are made in a variety of forms from rectangular to square or to a rectangular shape of different dimensions. It is important in the case of the latter that the piece be of ample length, so that the change from one shape to another will not be too abrupt, thus interfering with the passage of air. A transformation from rectangular to round is shown in Fig. 113.

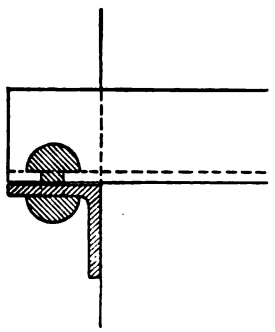

Fig. 112. Detail of Corner of Angle Iron Braces

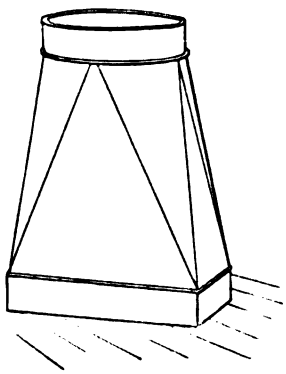

Fig. 113. A Transforming Piece

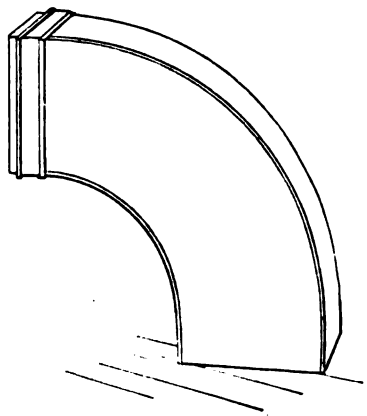

Fig. 114. Rectangular Square Elbow

In making rectangular bends it is always advisable to make them as easy as possible. Good practice determines that bends shall have an inner radius or radius in the throat equal to the diameter of the side of duct in the direction of the bend as shown in Fig. 114.

Dampers for controlling the flow of air should be placed in all branch pipes and connections, for in all heating and ventilating work it is impossible to foresee all conditions that may arise in erecting a piping system. Adjustable dampers must be used to secure the desired distribution.

Fig. 115 shows an approved form of adjustable damper and fittings which can be used on round or rectangular ducts. Damper braces are made of cast iron and holes for riveting to the damper and for the damper rod are cored in the casting. The top of the brace is tapped out to receive a set screw for setting down on the damper rod. Screw castings are cast with a hole for the damper rod and holes for riveting to the ducts are cored in the casting, and the hole is tapped out to receive a set screw for adjusting the damper. The damper rod is made from stock wrought rod and generally made $\frac{3}{8}$ in. in diameter for small dampers and about $\frac{1}{2}$ in. for large dampers. Damper braces are also made in two sizes, for large and small dampers.

Deflecting dampers are commonly used in ducts, at branches. These are commonly called switch dampers and the type is illustrated in Fig. 116.

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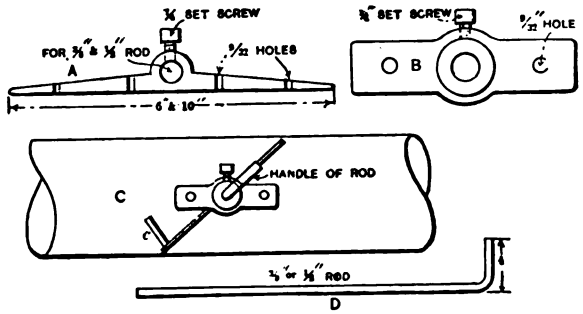
In factory buildings of slow burning construction, hangers can be made up as shown in Fig. 117, when the ducts run at right angles to the floor beams. Where piping runs parallel to the floor beams a straight hanger of bar iron can be used by bending about 4 in. of the bar at right angles and fastening to the tongued and grooved flooring by at least two lag screws. This type is shown in Fig. 118.



A BRACE FOR LARGE DAMPER
B " " SMALL "
C DAMPER IN ROUND PIPE
c STOP TO PREVENT DAMPER CLOSING OTHER WAY
D DAMPER ROD

Fig. 115.

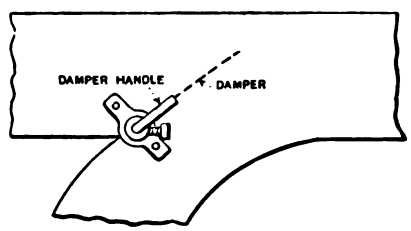


Fig. 116.

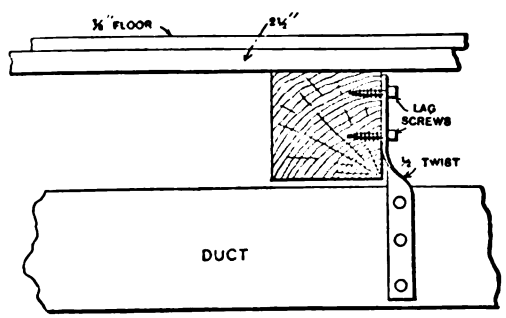


Fig. 117.

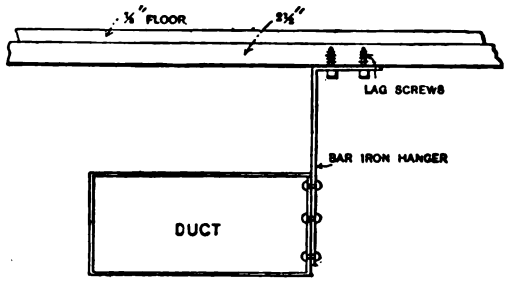


Fig. 118.

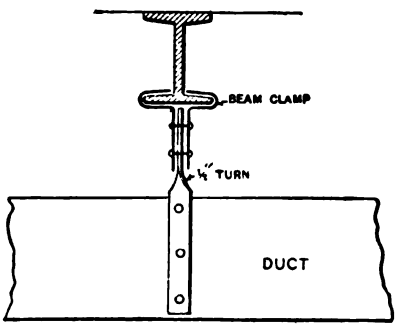


Fig. 119.

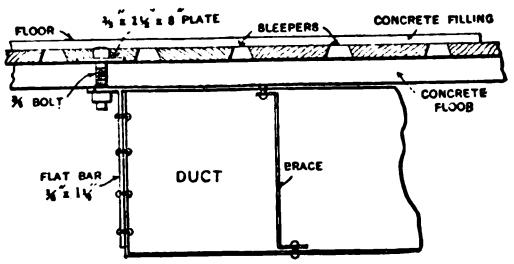


Fig. 120.

Types of Dampers and Hangers for Air Ducts

In buildings of fireproof construction, when the piping runs at right angles to the floor beams, a hanger of the type shown in Fig. 119 may be used to good advantage. One half of the beam clamp can be made as part of the hanger and the remaining half of the clamp made up and bolted fast. Fig. 120 shows one method of hanging ducts from a concrete floor. The vertical irons riveted to the sides of

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the ducts are turned at right angles at the top and are drilled to receive the bolts passing down through the floor.

ESTIMATING THE WEIGHTS OF RECTANGULAR AND ROUND PIPING AND SPECIFICATIONS

As to gauges of galvanized iron commonly used, the following are taken from a United States Government specification:

Round pipes up to 13 in. in diameter	No. 24 gauge
Round pipes 14 to 30 in. in diameter	No. 22 gauge
Round pipes 31 to 48 in. in diameter	No. 20 gauge

The following are taken from the specifications of prominent engineers:

Round pipes smaller than 12 in	No. 26 gauge
Round pipes 13 to 20 in	No. 24 gauge
Round pipes 21 to 24 in	No. 23 gauge
Round pipes 25 to 30 in	No. 22 gauge
Round pipes 31 to 44 in	No. 20 gauge
Round pipes 45 in. and larger	No. 18 gauge
Round pipes smaller than 26 in	Nos. 24 or 26 gauge
Round pipes 26 to 36 in	No. 22 gauge
Round pipes 37 to 48 in	No. 20 gange
Round pipes 49 in. and larger	No. 18 gauge

One prominent blower company uses these gauges:

Round pipes 3 to 8 in	No. 28 gauge
Round pipes 9 to 14 in	No. 26 gauge
Round pipes 15 to 20 in	No. 25 gauge
Round pipes 21 to 26 in	No. 24 gauge
Round pipes 27 to 35 in	No. 22 gauge
Round pipes 36 to 46 in	No. 20 gauge
Round pipes 47 to 60 in	No. 18 gauge
Round pipes 60 in. and larger	No. 16 gauge

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The accompanying table, Fig. 121, compiled from *Metal Worker* is of immeasurable value for quickly figuring weights of rectangular piping. It is to be understood though, that one gauge only is given for each size.

The weight of elbows, agreeing to the gauges represented for the rectangular piping, can be estimated quickly by computing the weight of a length of straight pipe equal to that of the center line of the elbow.

The weight is given in pounds per running foot, and the table covers all sizes from 2×2 in. to 60×60 in. The outer lines of figures are dimension figures; all other figures denote weights in pounds. It is obvious that all pipes having the same circumference must be of the same weight, provided, of course, that they are made of the same gauge of metal. Therefore, to avoid a repetition of figures and in consequence, considerable confusion, diagonal lines are drawn across the sheet, each line representing a certain weight, which weight is indicated at each end of the line at intervals throughout its length.

To find the weight of a rectangular galvanized iron pipe of any size, find one dimension in inches in one of the horizontal (top or bottom) lines of figures, and the other dimension in one of the vertical side lines of figures; at the intersection of the columns headed by these figures will be found either a figure denoting the weight in pounds per running foot or a diagonal line which, when followed, terminates in a figure denoting the weight. For example, let it be required to find the weight per foot of a pipe 16×24 in. Find in the upper line the figure 16 and in the side line the figure 24, follow the columns and the space at their intersection is found to be crossed by a heavy diagonal line; follow this line in either direction and the figure 12.9 is found, which denotes the weight in pounds per running foot.

The diagonal lines are made alternately heavy and light to aid the eye in following them. This table has been in use for a number of years by one of the larger blower companies, and has been found in practice to agree closely with the weight of metal used in actual installations and it has also been recommended for its accuracy by readers of aforesaid journal.

The following gauges are represented: From 2×2 in. to 6×6 in., No. 26; from 7×7 in. to 12×12 in., No. 24; from 13×13 in. to 20×20 in., No. 22; all above 20×20 in., No. 20. This represents about the average of the gauges used for fan work, the larger sizes requiring internal bracing. An allowance has been made for seams, laps, sleeves, rivets and solder, and waste when pipes are made from sheets 30×96 in. Reverting to what was previously stated in the matter of gauges, it is to be remembered that these weights may be readily converted into other gauges by using the usual factors.

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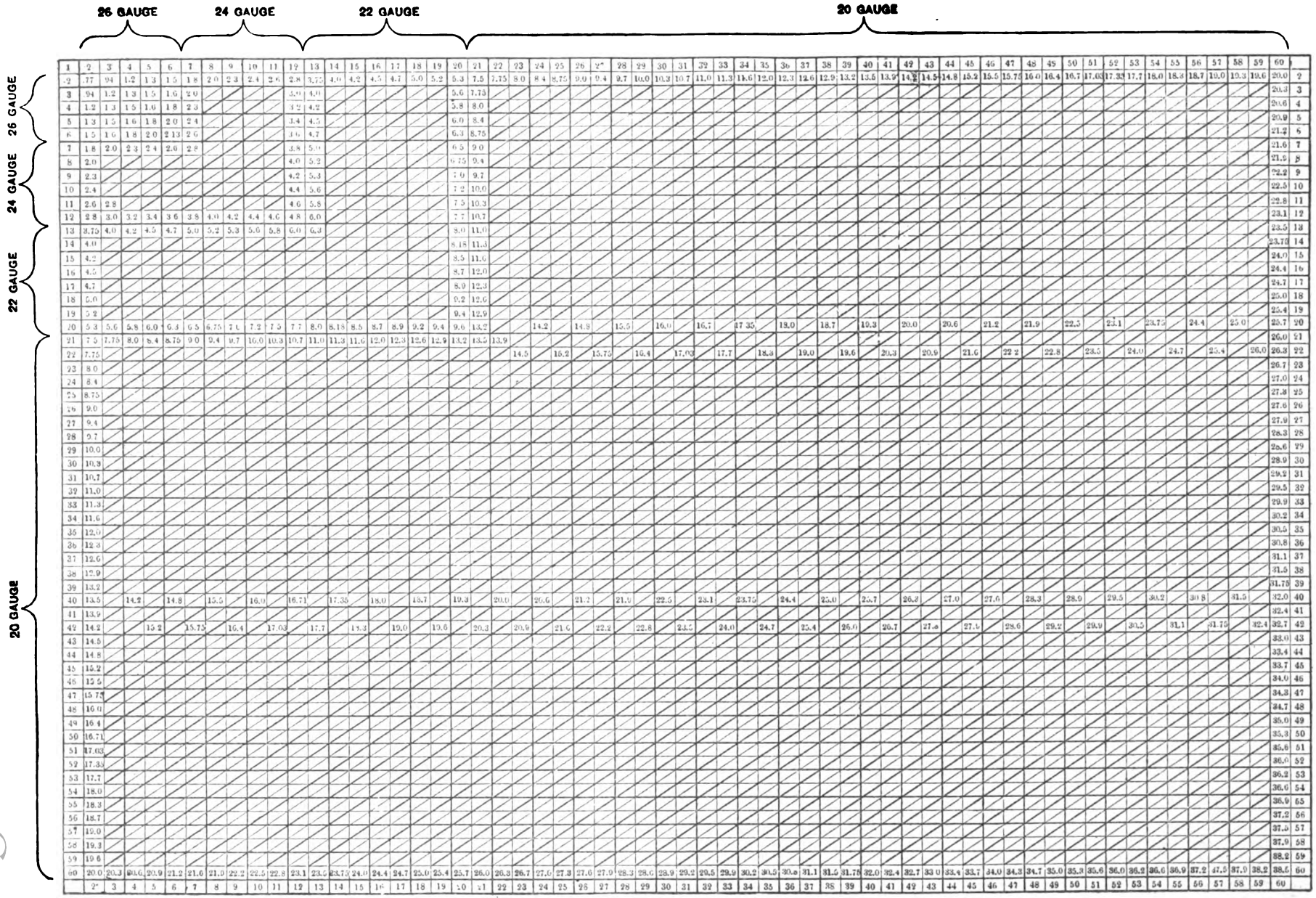

Fig. 121. Chart for Ascertaining Weight of Rectangular Galvanized Iron Pipe

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The following table is reprinted from the book, "Furnace Heating":

TABLE I—WEIGHT OF GALVANIZED IRON PIPE, THE AREAS AND CIRCUMFERENCES OF CIRCLES

Diameter Pipe Inches	Approx. area Sq. Inches	Circumference Inches	Weight of pipe per running foot						
			No. 28 gauge	No. 26 gauge	No. 24 gauge	No. 22 gauge	No. 20 gauge	No. 18 gauge	No. 16 gauge
1	0.7854	3.14	....	....	....	....	....	....	....
2	3.1416	6.28	....	....	....	....	....	....	....
3	7.07	9.42	0.7	....	....	....	....	....	....
4	12.57	12.56	1.1	....	....	....	....	....	....
5	19.64	15.70	1.2	1.4	1.8	....	....	....	....
6	28.27	18.84	1.4	1.7	2.1				
7	38.49	22.00	1.7	2.0	2.5	The heavy faced figures indicate the			
8	50.27	25.13	1.9	2.2	2.8	weight of pipes commonly built of			
9	63.62	28.27	2.1	2.4	3.1	the gauge stated at the head of the			
10	78.54	31.41	2.3	2.7	3.4	column in which they occur.			
11	95.03	34.55	....	2.9	3.7				
12	113.10	37.70	....	3.2	4.1	....	....	....	....
13	132.73	40.84	....	3.4	4.4	....	....	....	....
14	153.94	44.00	....	3.7	4.7	....	....	....	....
15	176.72	47.12	....	....	5.0	6.1	....	....	....
16	201.06	50.28	....	....	5.4	6.5	....	....	....
17	226.98	53.41	....	....	5.7	6.9	....	....	....
18	254.47	55.54	....	....	6.0	7.3	....	....	....
19	283.53	59.69	....	....	6.3	7.7	....	....	....
20	314.16	62.83	....	....	6.8	8.2	....	....	....
22	380.13	69.11	....	....	7.3	8.9	....	....	....
24	452.39	75.39	....	....	8.0	9.7	11.5	....	....
26	530.93	81.68	....	....	8.7	10.6	12.4	....	....
28	615.75	87.96	....	....	9.4	11.4	13.4	....	....
30	706.86	94.24	....	....	10.0	12.2	14.4	18.7	....
32	804.25	100.53	....	....	....	13.0	15.3	20.0	....
34	907.92	106.81	....	....	....	13.9	16.3	21.2	....
36	1017.88	113.00	....	....	....	14.6	17.2	22.4	....
38	1134.12	119.38	....	....	....	15.5	18.2	23.7	....
40	1256.64	125.66	....	....	....	16.2	19.1	24.9	30.7
42	1385.45	131.94	....	....	....	....	20.1	26.1	32.2
44	1520.53	138.23	....	....	....	....	21.0	27.4	33.7
46	1661.91	144.51	....	....	....	....	22.0		35.2
48	1809.56	150.79	....	....	....	....	22.9	29.8	36.7
50	1963.50	157.08	....	....	....	....	23.9	31.0	38.2
52	2123.72	163.36	....	....	....	....	....	32.2	39.7
54	2290.23	169.64	.... The diameter squared ×0.7854=area of a circle					33.6	41.4
56	2463.01	175.93	....	....	....	....	....	34.9	43.0
58	2642.09	182.21	.... The diameter ×3.1416=circumference of a circle					36.1	44.5
60	2827.74	188.49	....	....	....	....	....	37.4	46.0

Weight of Galvanized Iron Sheets in pounds per square foot, United States Government Standard

Gauge	28	26	24	22	20	18	16
Weight in pounds	0.78	0.91	1.16	1.41	1.66	2.16	2.66

In regard to rectangular pipe, custom varies considerably in the gauges used; if properly stiffened, lighter gauges may be used than for round pipes of the same area.

The following is taken from a United States Goverment specification: Rectangular ducts not exceeding 40 in. in width are to be made of No. 24 gauge; those wider than 40 in. to be made of No. 20 gauge. All surfaces of ducts 24 to 39 in. wide are to have V-shaped stiffening ribs, riveted in place outside of the ducts, spaced not over 30 in. apart. All ducts having a surface of 40 in. or over in width or depth must have 1×1×3-16 in. angle iron frames around them riveted to the ducts and spaced not over 30 in. apart. The ends of the various sections of ducts

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are to be finished with $1\frac{1}{4} \times 1\frac{1}{4} \times \frac{1}{4}$-in. angles. All ducts must be practically airtight when finished.

A specification for one of the largest department stores in the country states: Galvanized iron ducts 4 ft. square and greater are to be made of No. 22 gauge, smaller ones of No. 24 gauge. All joints are to be riveted airtight. All stiffening frames are to be of angle iron, painted. No wood construction allowed. Ducts must be thoroughly stiffened with 1-in. angle irons spaced not more than 4 ft. apart.

WEIGHTS AND THICKNESSES OF AMERICAN TIN PLATES

It is of interest to compare the weights of galvanized sheets stated in Table I with those of tin plates given in Table II, which is reprinted from *Metal Worker*.

TABLE II—WEIGHTS AND THICKNESSES OF TIN PLATES

Denomination Pounds	Weight per box of 112 sheets, 14×20 inches—Pounds	Approximate weight per square foot in decimals of pound	Thickness in decimals of an inch
55	55	0.252	0.00625
60	60	0.275	0.00638
65	65	0.3	0.0075
70	70	0.321	0.008
75	75	0.344	0.0086
80	80	0.367	0.0092
85	85	0.39	0.0098
90	90	0.42	0.0105
95	95	0.436	0.0109
100	100	0.46	0.0115
IC	108	0.5	0.0125
IX	136	0.625	0.0156
IXX	156	0.71	0.0178
IXXX	176	0.8	0.02
IXXXX	196	0.9	0.0225
IXXXXX	216	1	0.025

FINDING TRUE ANGLES IN BLOWER CONNECTION

In Fig. 122 is shown the side and plan views of two fan collars connected to one discharge pipe, and it is desired to find the true angle of the Y and the elbows. The size of the fan collars indicated by H and H in plan and H^1 in side view is to be as indicated, connecting to an 18-inch round pipe in the form of two elbows, as shown in plan, which in turn connect to a 25-inch pipe by means of a Y. The large discharge pipe passes through the wall at an angle of 54 degrees. The distance from the fan collar to the wall is 4 feet 6 inches and the hight from the bottom of the collar to the opening in the wall 3 feet 2 inches. The distance between the inside of the two fans is 2 feet, as shown in plan.

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Having drawn the side and plan views in their proper relative positions, as shown, the true angle of the Y is obtained as follows: Draw the center line through the side view, as shown by the dotted line *r n f v*; also the center line in plan, as shown by *n i d c*. From *n* in elevation drop a vertical line intersecting the center line *y n* in plan at *i*; also from *f* in elevation drop a vertical line cutting the center lines in plan at *d* and *s*.

Parallel to *r n*, in side view, draw any line, as D E, which intersect by a perpendicular dropped from *f* at E. Take the distance from *s* to *d* in plan and place it, as shown, from E to *d'* and from E to *d''*. From *n* in side view, perpendicular to E D, draw a line intersecting E D at B. From B draw lines to *d'* and *d''*. Then will D B *d'* and D B *d''* be the center lines of the Y. On either side of D B place one half of the 25-inch pipe and on either side of the center lines *d''* B and *d'* B place one half of the 18-inch pipes until the sides of the pipes intersect, as shown, which gives the true angles. The pattern for this Y must be developed by triangulation.

To obtain the true angle of the elbow shown by *f v* in side view and *d c* in plan proceed as follows: From *v* and *f* draw horizontal lines, as shown, intersecting the perpendiculars dropped from *f* and *n*. At right angles to *d i* in plan draw *i n''* equal in hight to *b n* in side view. Then *d n''* in plan shows the true length of *d i*.

Take the distance from *c* to *i* in plan and place it on the horizontal line shown by *c' i'* in (T). From *i'* erect the perpendicular *i' n'* equal to *m n* in side view and draw the line *n' c'* in (T). At right angles to *c d* in plan erect the perpendicular *d f''* equal to *e f* in side view. Then *f'' c* in plan is the true length of *d c* in plan.

With radius equal to *c f''* in plan, and *c'* in (T) as center, describe the arc *f'*, which intersect by an arc struck from *n'* as center and *n'' d* in plan as radius. Then *n' f' c'* in (T) is the true angle of the center line at point *d* in plan or at *f* in side view. If it is desired to place an elbow between the points *f* and *v* in side view, draw a graceful curve between the points M L and N O in (T), as shown, at a distance of 9 inches on either side of the points *f'* and *c'*, and make the elbow L M N O into any desired number of pieces. A slip joint is placed between *a* and *b* in side view to allow the work to be fitted as desired.

PUNCHING SHEET IRON

All who have made riveted smoke stacks, furnace drums or other heavy sheet iron work, have had more or less trouble in getting the holes in the two ends of the

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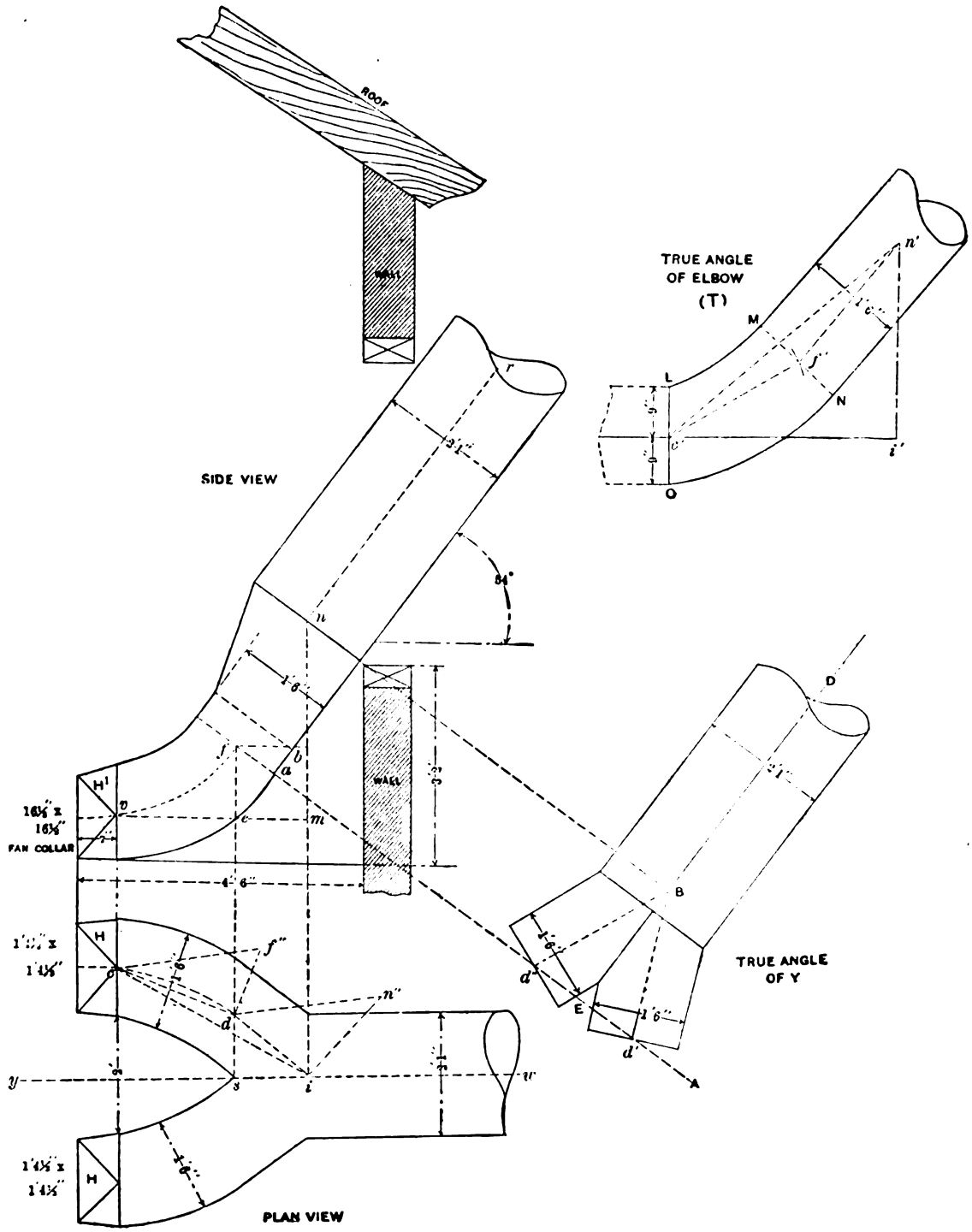

Fig. 122. Method of Finding True Angles

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sheet so that they would match perfectly. If punched on a lead cake or nut the punch is likely to get off of the mark that has been made with the template, and when the time comes to do the riveting a great deal of labor is spent in reaming the hole so that the rivet will enter. This method of punching also raises a burr that must be flattened down when the rivet is in place, or before it is inserted, if a neat flat tight seam is desired. A good workman has often longed for a gang punch when he has had a lot of such work to do. The device shown in Fig. 123 has been in use in the sheet iron shop for punching heavy sheet iron work. It consists of a heavy casting with lugs cast at each end, as shown. This serves as a bed plate and is drilled at proper intervals with ½-inch holes. On the top of this bed plate arrangement has been made to secure steel plates by means of set screws.

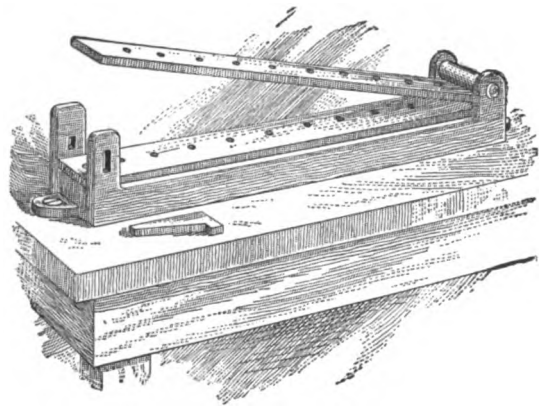

Fig. 123. A Device for Punching Sheet Iron

These steel plates are drilled with holes of different sizes to suit the punches used for different sizes of rivets. The lugs at each end of the bed plate serve to form a hinge for templates which correspond with the holes in the steel plates used. This template shuts down accurately over the holes in the steel plates and on top of the iron to be punched. It is secured in place by a wedge pin, which is driven in the oblong slots that are made in the lugs at the opposite end of the bed plate. By this means the iron is held from slipping while the holes are punched clean and accurately, so that when the sheet is formed the holes in the two ends match each other perfectly and there is no trouble in putting the rivets in them without reaming. After this is done it is simply a matter of labor with the heavy hammer to do the riveting.

LINING ELEVATOR BINS WITH HEAVY SHEET IRON

Herein it will be endeavored to tell the manner in which certain elevator bins were lined. These bins averaged from 8 ft. sq. to 15 ft. sq., and were constructed of timbers about 6 in. sq., laid on top of each other, and notched together at the intersection and doweled intermediately as indicated in Fig. 124. The bottoms of the bins were slanted in as indicated in Fig. 125. The bins were not all square

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and the outlet *a*, Fig. 125, was not always in the center of the bin. There were a number of groups of different sizes and some were used for corn, others for wheat, etc. The grain is poured into the bins by being mechanically carried to the top of the building, where it is dumped into a weighing device, from which it flows into the bins. Outlet *a* is connected with a chute for drawing the grain from the bins, the chute being provided with a slide valve.

While the friction of the grain against the vertical sides of the bin is not sufficient to warrant lining it throughout the entire hight, the friction on the sloping parts of the bottom is so great that the woodwork is rapidly worn away. In order to prevent this wearing, the bin bottoms were lined with No. 16 galvanized iron. Owing to the variation in size and shape of the bottoms, it was impossible to order sheets of any special size that would facilitate the work and save material. The iron was therefore ordered in sheets 30 × 96 in., and it required over 700 sheets.

There was much discussion between the proprietors and the foreman as to the best methods of procedure, that is, whether it was better to have the material delivered to the elevator, direct, and have all work done there, or to deliver it to the shop for preparation. It was finally decided that it would be better to measure the bins, numbering each one and lettering each side, and cut, punch and form the material at the shop, where the work would be under the supervision of the foreman, and where everything would be convenient and comfortable.

The bins were measured as follows, each one being treated separately and independent of any other. A plan and surfaces of the four sides expanded, as indicated in Fig. 126, were made of each bin. The bin indicated is No. 1. These sketches and dimensions were made in a notebook at the building from measurements of the woodwork, after the bin bottoms were complete ready for lining. A sketch drawn to 1½-in. scale was then made, showing what was roughly sketched in the notebook, and the lines *a*, *b*, *c*, *d* drawn on the expanded sides A, B, C, D, as indicated in Fig. 127. The material being 30 in. wide and 1 in. being allowed for laps, the lines *a*, *b*, *c*, were spaced 29 in. apart.

As there were to be a great many different sizes to lay out on the same floor space, it was necessary to devise some way of doing it that would not require the making of lines on the floor, as the lines would soon become so numerous as to be confusing. A way was therefore schemed out, as indicated in Fig. 128. Lines *a a*, *b b*, *c c*, *d d* and *e e* were chalk lines marked on the floor, and they were made about 18 ft. long and just 29 in. apart. Two strips of metal were then cut 4 in. wide and 8 ft. long and joined together, making a straight strip 16 ft. long, as shown by *f*; four other strips of the same width were also cut and joined together

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in pairs, making the two straight strips *g* and *h*. One inch from one edge of *g* and *h*, respectively, lines were struck, as indicated by *i* and *k l*.

In laying out one side of the bin take A, for instance. The 10-ft. dimension was laid off on line *a a*, as indicated at *m m'*. Straightedge *f* was then placed 6 ft. 4¼ in. from line *a a* and secured by nails tacked to the floor through each end. A trammel was then set to the 7 ft. 9 in. dimension, and from *m* and *m'*, as centers, arcs were struck against the edge of *f*, locating the points *n* and *n'*. The distance *n n'* should be just 12 in., and if a slight variation was found, the difference was distributed on each side, but it was found that when measurements were taken accurately there was hardly ever a discrepancy that amounted to anything. One of the other straightedges was then laid with its edge against *m* and *n* and tacked to the floor and the third straightedge laid against *m* and *n'* and tacked to the floor. Thus the surface outline by *m m'*, *n* and *n'* was an exact full size development of side, A, and the chalk marks *a a*, *b b* and *c c* were the line of the upper edge of the sheets.

The lines *i j* and *k l* struck on the straightedges *g* and *h* were the allowance for laps to be turned at the valley corners of the bins on opposite sides. Thus, sides A and C had laps on each side, while sides B and D were cut off on the line *m n* and *m' n'*.

After locating the straightedges the next step was to lay a sheet of iron in position at O, as indicated by the dotted lines. A straightedge was then laid on the sheet and brought even with line *m n*, and a line scribed across, which was where the sheet was to be bent at the valley. The straightedge was then pushed back 1 in. in line with *i j*, and the sheet scribed across for cutting. Another sheet, P, was then laid in position, overlapping O 1½ in. This sheet was similarly scribed on line *m'* and *n'* for bending, and on line *k l* for cutting. The piece P' which was thus cut off was then laid in position at Q, it having been turned over so that the miter line would just fit line *i j*, it then being only necessary to scribe line *m n* to locate the bend. Lines *m' n'* and *k l* were then struck and piece Q' was cut on *k l*, which was similarly turned over and placed in position R.

It will be seen that this completed side A, with the exception of the small corner R', which was cut from the scrap which fell from R. It will thus be seen that there was practically no waste of material.

All sides of all the bins were consecutively laid off and cut in this manner. Letters are used in describing the operation, but the pieces were marked 1 A 1, 1 A 2, 1 A 3, 1 A 4, 1 A 5, as shown, the first figure indicating the number of the bin, the letter indicating which side of the bin, and the last figure indicating the number and location of the piece of that particular side.

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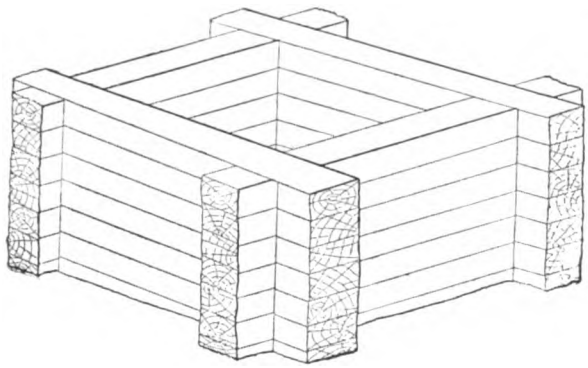

Fig. 124

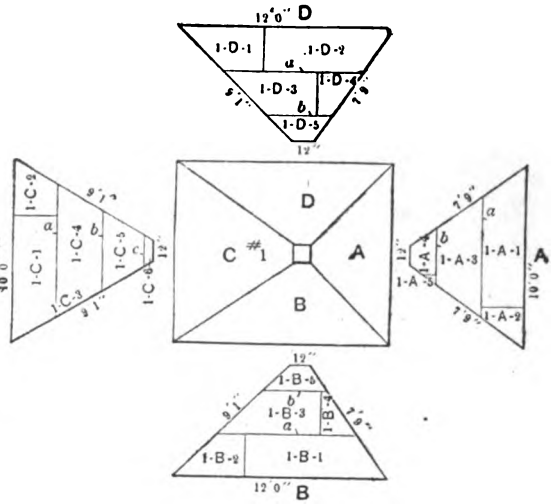

Fig. 127

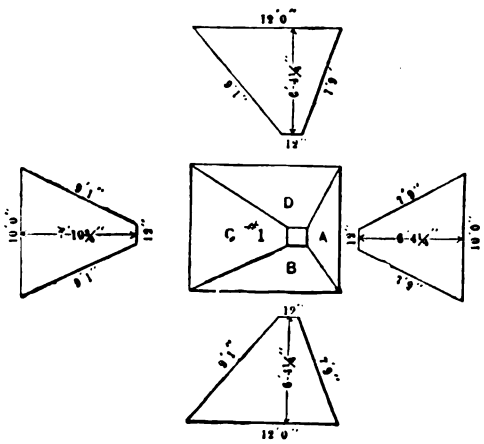

Fig. 126

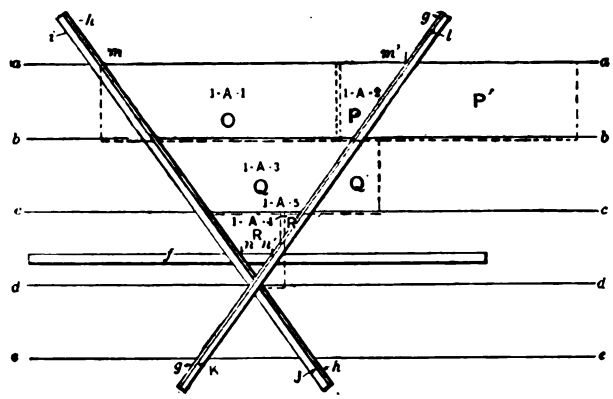

Fig. 128

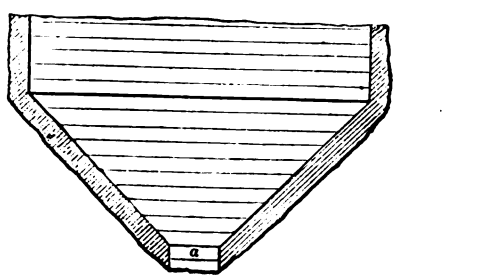

Fig. 125

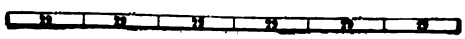

Fig. 139

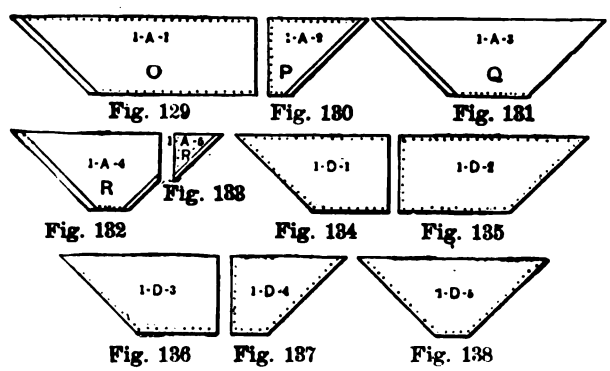

Fig. 129 Fig. 130 Fig. 131

Fig. 132 Fig. 133 Fig. 134 Fig. 135

Fig. 136 Fig. 137 Fig. 138

Laying Out Galvanized Iron For Bin Bottoms

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The straightedges were then shifted to form a full size outline of the next side of the bin—for instance D. As soon as a side was laid out so that the cross seams and number of pieces could be located and determined, they were properly marked on the scale drawing, Fig. 127. It will be seen that the expanded side A of Fig. 127 shows the number of pieces just laid out in full size, and is correspondingly marked. In laying out and cutting the material the edges which were to be punched for nailing, as described below, were also marked. The side of the metal on which the marking was done indicated that it was the upper surface. All marking was done with a solution of copper and acid.

After the different pieces were cut and identified by marking they were punched on one side and one end for nailing. The top courses were, of course, punched on both sides. Two-inch wire nails were used, spaced about 3 in. apart. Fig. 129 indicates how piece O (1 A 1) was punched; Fig. 130 indicates how P (1 A 2) was punched; Fig. 131 indicates how Q (1 A 3) was punched; Fig. 132 shows how R (1 A 4) was punched, and Fig. 133 shows how R′ (1 A 5) was punched. The upper edges and the straight ends of Q and R were not punched for the reason that it was found that while two thicknesses could not be pricked, a nail hole could be pricked through one thickness of the iron after it was laid in

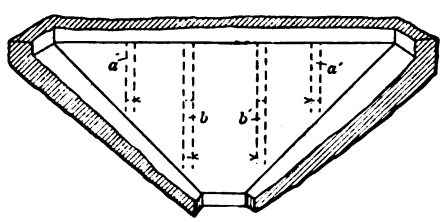

Fig. 140

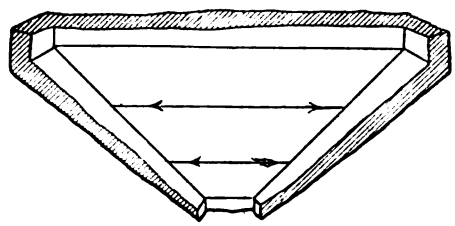

Fig. 141

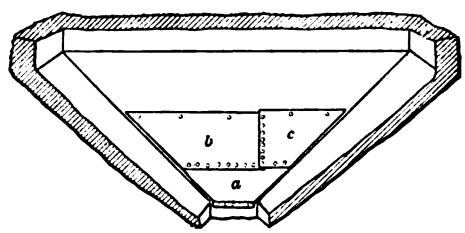

Fig. 142
Method of Laying Sheets in Bin

position on the solid heavy timbered bottoms of the bins, so that in laying the iron the unpunched edges were prick punched by means of a stout, well tempered sharp pointed punch and a heavy hammer, through the holes in the punched lower edges of O and Q, and square ends of P and R′, Fig. 128.

Referring to side D, Fig. 127, Fig. 134 indicates how piece 1 D 1 is punched. This piece is punched along its miter cut where it laps over and nails through the

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1-in. lap edges turned on the miter pieces of sides A and C. Fig. 135 shows how 1 D 2 is punched; Fig. 136 shows the punching of 1 D 3; Fig. 137 shows the punching of 1 D 4, Fig. 138 shows the punching of 1 D 5. After being cut and punched, the miter pieces of the sides which carried the 1-in. laps along the valleys had this lap turned up a little more than half square, in the cornice brake.

When the material was ready it was sent to the building and nailed into the bins in the following manner: Two long strips of metal were provided, and marked as indicated in Fig. 139, the strips being about 1 in. wide and the spacings 29 in. apart. These strips were used to lay off the horizontal course lines, in the bins.

Referring to Fig. 140, which represents a sectional perspective view, looking into one of the bins, the strips were first laid in the position indicated by dotted lines *a* and *a'*, and marks made on the woodwork at the first 29-in. space, as indicated. The strips would then be shifted to *b* and *b'*, and further marks made lower down on the wood surface, as indicated, and points marked on the wood from the spacing lines on the strips. In handling the strips they were kept rolled up except that portion which was to serve as a spacing measure.

Chalk lines were then struck through the points thus established on the woodwork, as indicated in Fig. 141. These lines determined the location of the upper edges of the sheets. It was then feasible to lay the smallest and lowest piece in position first and secure with a few nails in the upper edge, as indicated at *a*, in Fig. 142; then the second piece, *b*, was laid in position overlapping the first piece, and having the upper edge coincide with the second chalk line and secured with a few nails in its upper edge, as indicated. Piece *c* was then laid. All the sheets were thus nailed along the upper edges before the next and overlapping sheet was put in place, so that in case the grain should ever wear off the nail heads that projected up through, the sheets would not slip down, because of being secured by the nails in their upper edges, which were protected from the action of the grain by the sheet overlapping them. The next operation was to punch holes in the unpunched underedges, through the holes which were machine punched, and the nailing done. This process was repeated with the other courses until the top of the bin bottom was reached.

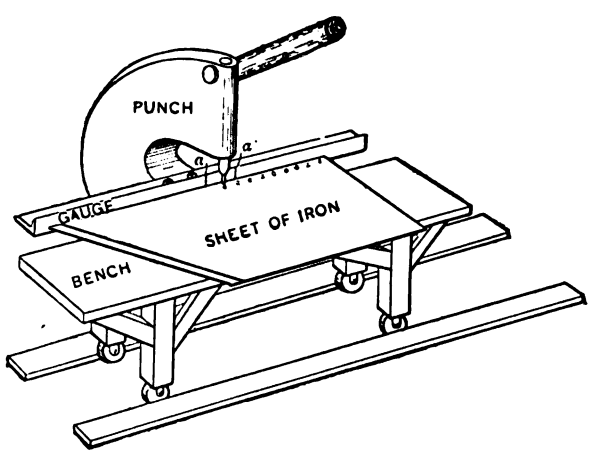

Fig. 143. Method of Punching the Sheets

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It was necessary to chalk line the bin for the spacing of the courses, as otherwise it would be easy to have allowed too much lap, and especially in view of the weight of the sheets and their insistence upon sliding down a trifle when securing, the result being that when the top and last course was laid, it would not reach to the top of the bin. Furthermore, the horizontal chalk lines were a help in keeping the pieces straight in position. While at first it seemed that there might be some confusion and difficulty in finding the proper pieces or keeping the pieces belonging to one bin from getting mixed up with those of another, the event proved that it was easy to keep the bins separate, and practically no time was lost in searching for the missing pieces.

Fig. 143 indicates how the sheets were punched. A rolling table, the upper surface of which was on a level with the lower die of the punch, was guided in tracks made by nailing strips of wood on the floor across the front of the punch. A long gauge was secured to the under jaw of the punch which guided the iron, so that the center of the holes would be ½ in. from the edge of the sheet. On this gauge were two marks *a* and *a'*, located 3 in. on each side of the punch. As accuracy to within ¼ in. in the spacing of the holes was not required, it was only necessary to lay the sheet on the table as indicated, and starting from one end punch a hole, then sliding the sheet along until the hole just punched came opposite to mark *a* or *a'*, according to whether the punching was being done from right or left, and punch a second hole, the second hole then being shifted opposite the mark and a third hole punched, etc. The punch was worked by a hand lever, and as the bench was easily moved along, a stout boy alone did all the punching. The pieces were marked on the edges to be punched, when being laid out.

GRAVEL ROOFER'S KETTLE AND FIRE PLACE

The thickness of the metal to be used depends upon the size of the kettle and fire place. Whatever thickness is used the construction can be similar to that shown in Fig. 144, in which A A shows the fire pot seamed to the bottom B B at C C. At the top of the fire pot an angle iron D D is riveted, as shown at *a a*. At E is the elbow, beaded and flanged as shown respectively by *b* and *c*, while F shows the damper in position.

The angle iron H H, riveted as shown, supports the grate J J, while K shows the opening for the ash pit door, around which grooves are riveted, into which the door will slide as shown by *e e*. The opening for the fire door is at L and around

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it grooves are riveted as indicated at *f f*. The tar kettle M M is double seamed to the bottom at N N, on the top of which an angle, O O, is riveted as shown by *i i*. The pitched cover P is seamed to the collar, as shown by R R. The handle S is riveted at *m m*. The wheels and axle T U T are fastened to the bottom of the fire pot, as shown in Fig. 145, in which A is part of the fire pot and B the section of the axle, which is fastened to the bottom by means of the angle C C, riveting at *a a a a*. The balance legs are shown at D D, one being fastened on either side of the fire pot and riveted at E and E, which forms a pivot.

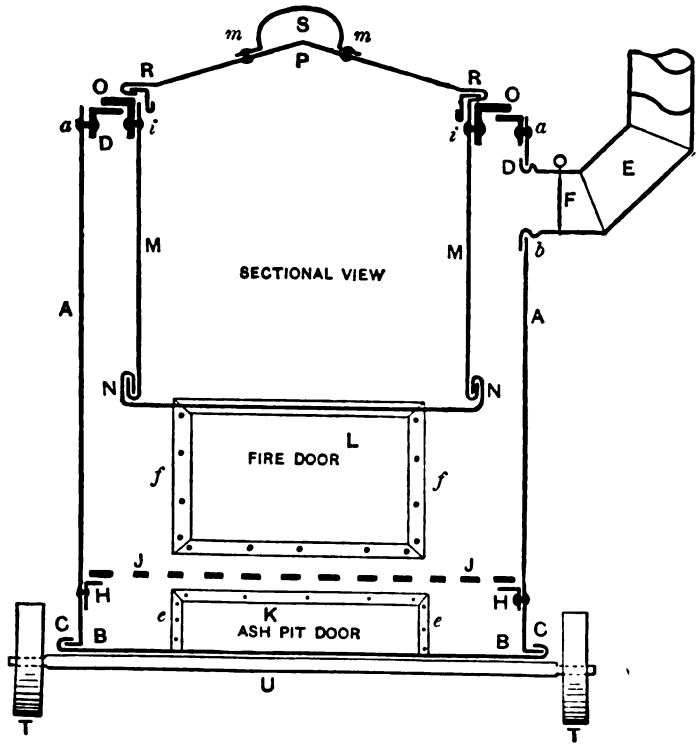

Fig. 144. Sectional View of Fire Place and Kettle

When the fire pot is to be wheeled to a certain place the legs D D are raised, and afterward lowered, thus preventing the kettle from tipping. Fig. 146 shows how the slides and grooves for the doors L and K in Fig. 144 are constructed, while A A in Fig. 146 shows the part body

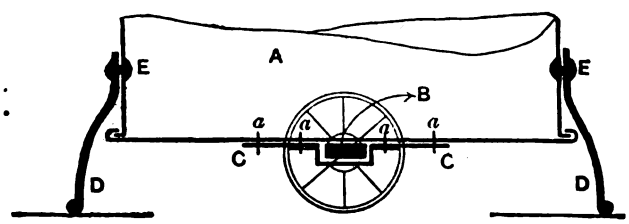

Fig. 145. Method of Fastening Axle and Balance Legs

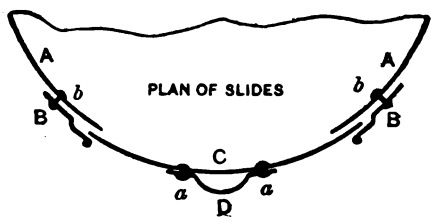

Fig. 146. Construction of the Slides

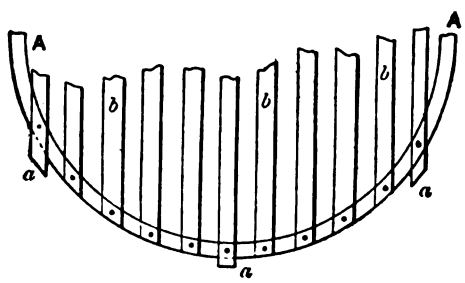

Fig. 147. The Grate Construction

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of the fire pot, cut out as shown from *b* to *b*. The riveted grooves are shown by B B, in which the door C slides, D being a handle riveted at *a a*.

Fig. 147 shows the construction of the grate, which can be made from band iron. The outside ring A A should be a trifle smaller than the inside diameter of the angle iron ring D D in Fig. 144, so that it can be removed when desired. Three of the grate bars, as *a a a* in Fig. 147, are to project over the ring as shown, these projections to rest on the angle iron H H in Fig. 144. The balance of the grate bars, as *b b b*, etc., in Fig. 147, are riveted. It will be noticed that the angle iron ring at the top of kettle in Fig. 144 rests upon the angle iron ring D D at the top of the fire pot. This allows the kettle to be removed for cleaning purposes. If desired, the fire pot and kettle can be made square, using the same construction, which, however, can be modified to suit.

POINTS ON WORKING HEAVY SHEET IRON

The following is a description of how a power punching machine was used in the working of heavy sheet iron. The method of making ice cans is used to illustrate how such work was handled, and it will be seen that the equivalent of many of the methods or operations can be applied to various other kinds of heavy work.

The cans were made of Nos. 16 and 18 galvanized iron, according to size, which was governed by the weight of the block of ice to be frozen, 100 lb., 200 lb., or 300 lb., these being the commonest sizes of blocks. For the benefit of those who may not be familiar with the manner in which the cans are used for making artificial ice, it is stated that the large vat of salt water containing the ammonia filled freezing pipes is floored over and openings left in the floor just the size of the can under the heavy wrought iron stiffening band. Fig. 148 is a view of a typical can. The cans are then filled with pure water and let down through the openings in the floor into the solution of salt water underneath, and covered. As the temperature of this solution can be and is reduced below 32 degrees, which is the freezing point, without congealing, whereas the pure water congeals at 32 degrees, the result is a solid block of ice in the can. The ice filled can is then raised, but by means of a traveling overhead tackle with hooks inserted in the holes in the sides and placed under a stream of warm water which melts the ice loose from the sides and bottom so the block will slip out. The can is made slightly tapering to facilitate this, and it must be perfectly smooth on the inside; no rivet heads, lumps of solder or buckles being allowed to project at all.

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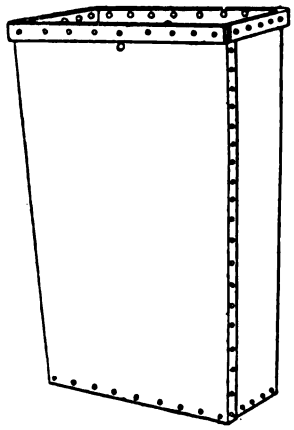

Fig. 148

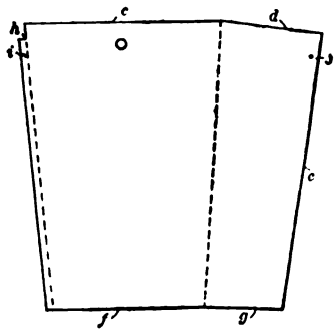

Fig. 149

Fig. 150

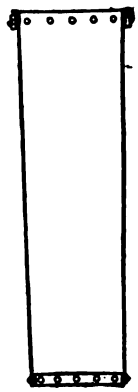

Fig. 151

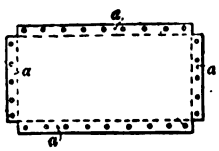

Fig. 152

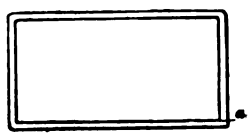

Fig. 154

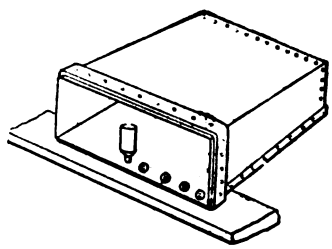

Fig. 155

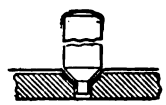

Fig. 156

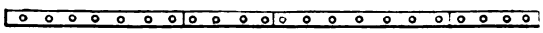

Fig. 153

Fig. 157

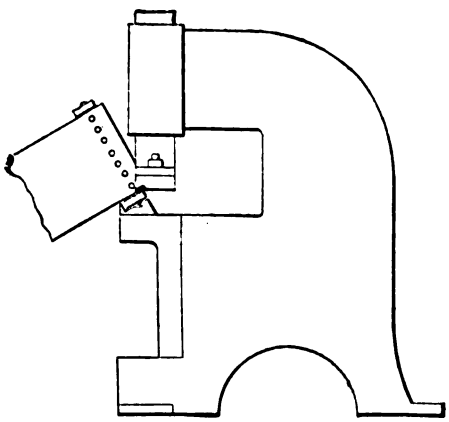

Fig. 158

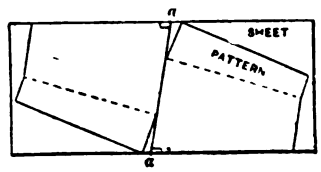

Fig. 159

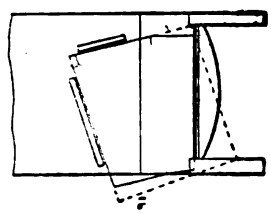

Fig. 161

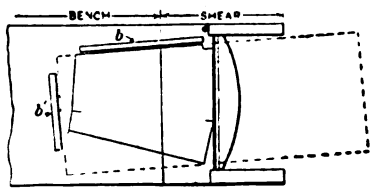

Fig. 160

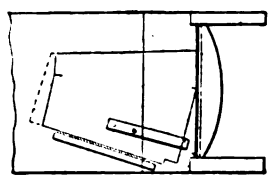

Fig. 162

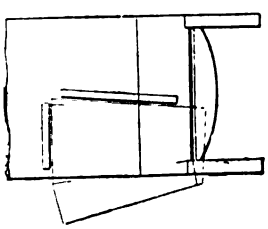

Fig. 163

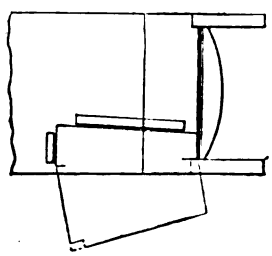

Fig. 164

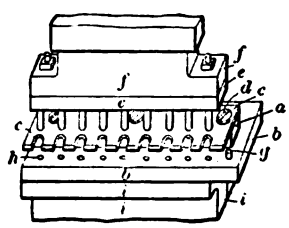

Fig. 165

Various Details in the Making of Ice Cans

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One size of can was about 11 × 22 in. at the top and 10½ × 21½ in. at the bottom and 44 in. high. Fig. 148 is a view of a completed can, which it will be seen is made in two pieces, with seams at diagonally opposite corners. Fig. 149 is a half pattern, Fig. 150 a horizontal section, Fig. 151 a vertical section and Fig. 152 a pattern of the bottom. The 1-in. edges, *a*, of the bottom, after being punched for riveting, are turned down square, and then slipped into the bottom of the can and riveted as indicated at Fig. 151.

The stiffening band was made of 1¼ × ⅜-in. iron, laid out, punched, and countersunk, as indicated in Fig. 153. It was then formed up, as indicated in Fig. 154, with the countersunk ends of the holes on the inside of the band and joint *a* welded. After the cans were formed and riveted together the stiffening bands were slipped over the top, allowing the sheet metal to project about 5-16 in. above the band. The can was then laid on a mandrel, as indicated in Fig. 155, and holes punched through the sheet metal by hand for riveting on the bands. Fig. 156 is a sectional view showing the form of punch used, which first punched a hole a trifle smaller than the rivets to be used, and by added blows of the hammer drove the sheet metal down into the countersink of the rivet holes in the band, so that the countersunk head rivets used would be laid in flush with the inside of the can, as shown in Fig. 157. Then the edge which was left projecting above the band was laid over square on top of the band by a special die in the punching machine, as indicated in Fig. 158.

The material was ordered of such a size that one complete can could be cut out of a sheet, as indicated at Fig. 159, and the cutting was done with a 36-in. gap shear by means of gauges, so that while the pattern was used to set the gauges by, no marking was done on the sheets. The first operation was the cutting of the sheet in half on the oblique line *a a*, Fig. 159. This was governed by gauges, *b* and *b'*, Fig. 160, which were temporarily but securely tacked to the bench that sat in front of the square shear and was permanently connected thereto. It will be seen that this cut not only severed the sheet, but made the cut *c* of pattern, Fig. 149, on both halves of the can. The solid lines show how the pattern was laid on the bench and against the blade of the square shear for setting the gauges, and the dotted lines represent the sheet.

Fig. 161 indicates how the gauges were set for making cut *e*. As the side of the can was about 44 in. long, while the square shear was 36 in., it was necessary after cutting the length of the blade on side *e*, to raise the material above the gauges, and push it along for the second bite of the shear, which finished cut *e*. Fig. 162 indicates how cut *d* was made; Fig. 163 shows the arrangement for cutting *f*; Fig.

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164 shows how *g* was cut. This completed a half side with the exception of notch *h*, Fig. 149, which was cut with a special notcher in the punch machine. Notch *h* was made the depth of the stiffening band plus the 5-16 in. edge, which was turned over. Similar cuts of all similar pieces were made at one time. For instance, if 500 cans were being made, 1000 cuts would be made at each set of the gauges.

The sheets were punched for riveting by a gang punch die arrangement in the punching machine; Fig. 165 is a front view of this, and Fig. 166 a longitudinal sectional view on center line of punches. The rivet laps on the bottom and sides of the cans were 1 in. wide and the center of the rivet holes was ½ in. from the edge. In Figs. 165 and 166, *a* is a gauge set ½ in. back from the center of the holes in the lower die *b*. The letter *c* is the stripper, made of ⅛-in. thick sheet iron and secured by screws *d*, which also secure gauge *a* to die plate *b*. It will be seen that the punches were provided with countersunk heads and were laid into the upper die plate *e*, which was attached to the plunger *f*.

The punching of the holes in the bottom of the can and in the bottom ends *f* and *g* of the body of the can was comparatively simple, but great accuracy was required in punching the holes for the side seams, as the slightest longitudinal discrepancy resulted in a twisted can, and it requires much longer to melt the ice out of a twisted can than one which is true. Breweries and factories usually reject twisted cans. In order to avoid twisting, the two first holes, *i* and *j*, Fig. 149, were accurately located, and made in the pattern, and after the sides were cut the pattern was carefully laid on same, so that the edges would match perfectly, and clamped in position, and the holes *i* and *j* machine punched through the holes in the pattern; the pattern being reinforced around holes, *i* and *j*, by a ⅛-in. thickness of band iron.

When side *e* was being punched, hole *j* was slipped over the projecting punch gauge *g*, Figs. 165 and 166, the center of this punch gauge being located just one rivet spacing from the first hole in die *b* (the rivets were spaced about 1¼ in. apart). The plunger was then brought down punching 9 or 10 holes, as indicated, then the sheet was pulled along, and the last hole punched at *h*, Fig. 165, was slipped over the guide punch *g* and the operation repeated until the entire side was punched. This process was repeated on the other side, starting with hole *i*. The bottom edges *f* and *g* of the body, Fig. 149, and the bottom piece, Fig. 152, were punched in a similar manner, so that when the can was formed ready for riveting, all holes matched perfectly. Countersunk head rivets were used.

The side seams of the cans were riveted by hand on a long mandrel. The rivets were inserted in the manner indicated in Fig. 167, it being necessary to slip

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the last rivet inserted onto the mandrel before putting in the next one, thus the mandrel held the rivets in as fast as they were inserted, and the cans gradually slipped onto the mandrel.

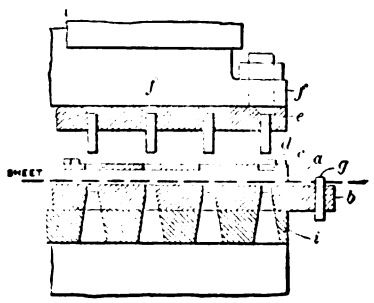

Fig. 166

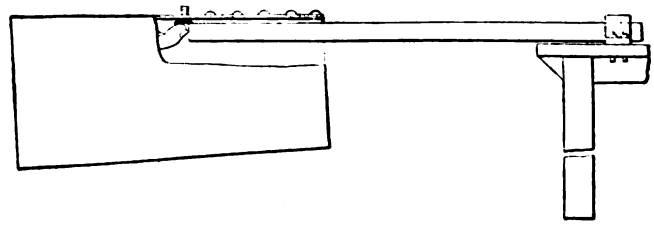

Fig. 167

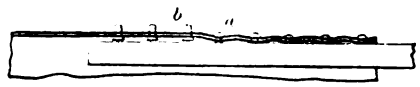

Fig. 168

Fig. 169

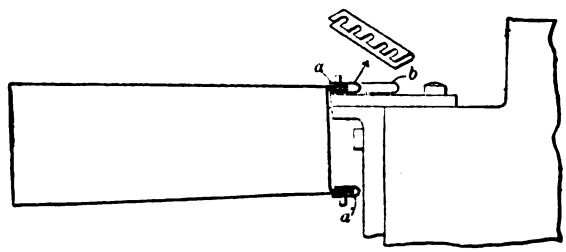

Fig. 172

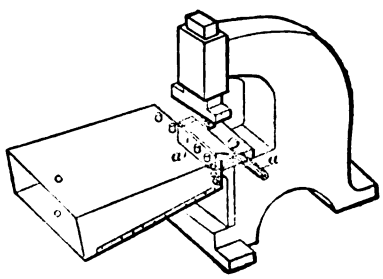

Fig. 170

Fig. 171

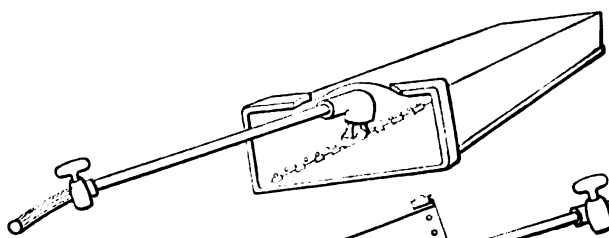

Fig. 173

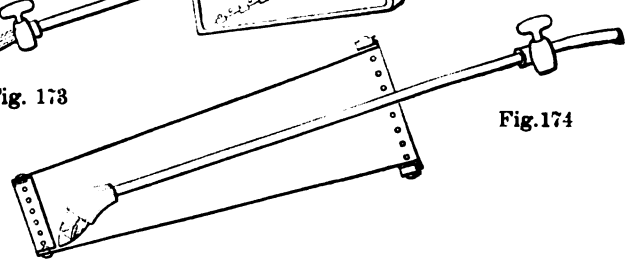

Fig. 174

Method of Riveting and Soldering Ice Cans

It was found that if all the rivets were put in before being drawn and headed up, the seam would be wavy on the inside, because when a rivet was set down as at *a*, Fig. 168, the next rivet *b*, not having been drawn, held the material up, which resulted in a kink and stretched the material so that it was difficult to get it

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to lie smooth. It was, therefore, found best to draw and head up each rivet as it was put in; one operator doing the riveting, while the other was inserting and assisting in holding the can in position.

Fig. 169 is a sectional view showing the bottom of the rivet sets used. The bottom of the cans was riveted in on the punching machine, as indicated in Fig. 170. Fig. 171 shows the gang set and header used under the plunger, as indicated by *a*, Fig. 170. The rivets were inserted in the bottom by hand and secured by clips, *a* and *a'*, Fig. 172. Then the can was laid in position on the mandrel of the punch, as shown in Fig. 172, and clips, *a*, pushed out of the way, as indicated by lines, *b*. Clips *a* were made the same length as the gang-set. All the rivets around the bottom were inserted and held in position by the clips before the can was put into the machine for riveting. The stiffening bands were gang-riveted on the top of the cans in the machine, in a similar manner, after which the edges were turned over, as indicated in Fig. 158.

The solder for the side and bottom seams was cut up into small pieces, and after the acid was applied these bits of solder were laid on the seam at intervals, as indicated in Fig. 173. A heavy hatchet forged gas heated soldering copper, as indicated in Fig. 173, was used for soldering the side seams on the inside of the can, and a similarly heated bent chisel forged copper was used for soldering the bottom seams on the inside of the can, as indicated in Fig. 174.

PATTERNS FOR IRREGULAR PIECED ELBOWS

This problem is how to obtain the true angle of the center elbow, B, shown in Fig. 175; for a rule for the center elbow where A, B and C are any given angles, and for the twist required for the elbows B and C to bring them in the proper position to punch holes for rivets before putting together. A B C shows the elevation of the elbows, and A^1 B^1 C^1 is the plan. Fig. 176 is a perspective view of Fig. 175.

In Fig. 177, draw the plan and elevation of the center line of the elbow, as shown. In this elevation A^2 A^1, B^1 C^1 and C^1 C^2 are the full size of the lines they represent, so A^1 B^1 is the only line the true length of which must be found. The true angle at C^1 is shown, so it will be only necessary to determine the true angles at A^1 and B^1. From A^1 draw the horizontal line A^1 D, intersecting C^2 C^1, extended at D. From B^1 drop a line intersecting A^1 D at E. Equal to and parallel to A B in plan draw A^3 B^2, at right angles to which lay off B^2 B^3 equal

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to E B^1 in elevation. Draw A^3 B^3, which is the true length of A B, or A^1 B^1. At right angles to B^2 A^3 draw A^3 A^4, equal to A^1 A^2; then will B^3 A^3 A^4 be the true angle of the elbow A^2 A^1 B^1 in elevation. On either side of the center line B^3 A^3 A^4 draw the pipe and the miter line 1′ 5′, as shown.

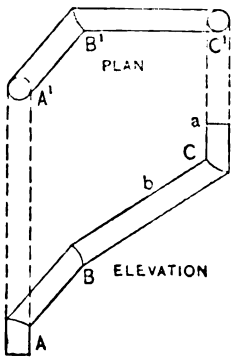

Fig. 175. A Sketch of the Problem

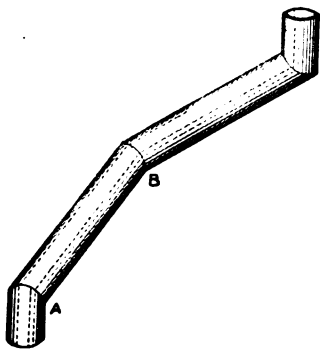

Fig. 176. Perspective View of Elbow

To obtain the true angle at B^1 in elevation proceed as is shown in Fig. 178. Draw any horizontal line, as A C, equal in length to a line drawn from A to C in Fig. 177. Take the vertical hight from the points A^1 to C^1 in elevation, as D C^1, and place it in Fig. 178 on a line drawn from C at right angles to C A, as C C^1. Draw C^1 A, the true length between A and C in plan in Fig. 177. The true angle is obtained by using as radius A^3 B^3 in Fig. 177, and with A in Fig. 178 as center, describing the arc B. Then, with a radius equal to B^1 C^1 in Fig. 177, and with C^1 in Fig. 178 as a center, describe an arc intersecting the arc previously drawn at B. Draw a line from A to B to C^1. Then will A B C^1 be the true angle of the elbow shown by A^1 B^1 C^1 in elevation in Fig. 177.

The next step is to construct a developed elevation in which the true miter lines are obtained, as shown in Fig. 179. Take a tracing of A^4 A^3 B^3 in the oblique elevation in Fig. 177, and place it as shown by A A^1 B in Fig. 179; then take a tracing of the true angle A B C^1 in Fig. 178 and place it in Fig. 179, placing the line A B of Fig. 178 over the line A^1 B in Fig. 179, and obtain A^1 B C. As B^1 C^1 C^2 in elevation in Fig. 177 is the true center line and angle of that elbow, take a tracing of same, placing the line B^1 C^1 over the line B C in Fig. 179, and obtain B C C^1. Then will A A^1 B C C^1 be the developed center line with the true angles of the full elbow. On either side of the center line in Fig. 179 lay off the half diameters and draw side and miter lines.

In its proper position draw the profile of the pipe A^2. Assuming that the seam is to come at the point 1 in the plan A in Fig. 177, divide A^2 in Fig. 179

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into an equal number of parts, and start to number same on the shortest side of the first piece of pipe, A A^1, as shown in plan at 1, which corresponds to point 1 in the plan A in Fig. 177. From the various intersections, 1 to 8 in plan, erect lines into the elevation, cutting the miter line 1′ 5′, as shown; from which, parallel to A^1 B, draw lines intersecting the miter line 1″ 5″, as shown. Continue these lines parallel to the center lines in the other pieces of the elbow in the usual way.

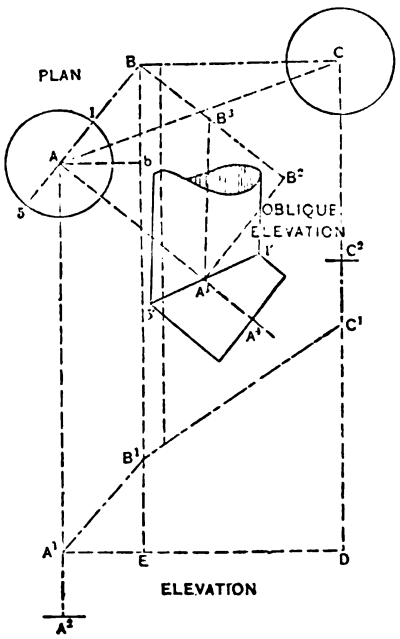

Fig. 177. Plan and Elevations

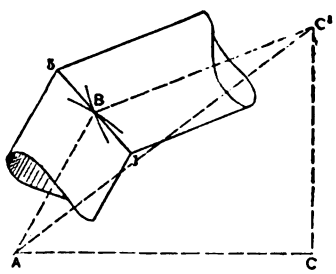

Fig. 178. True Angle at B^1 in Fig. 177

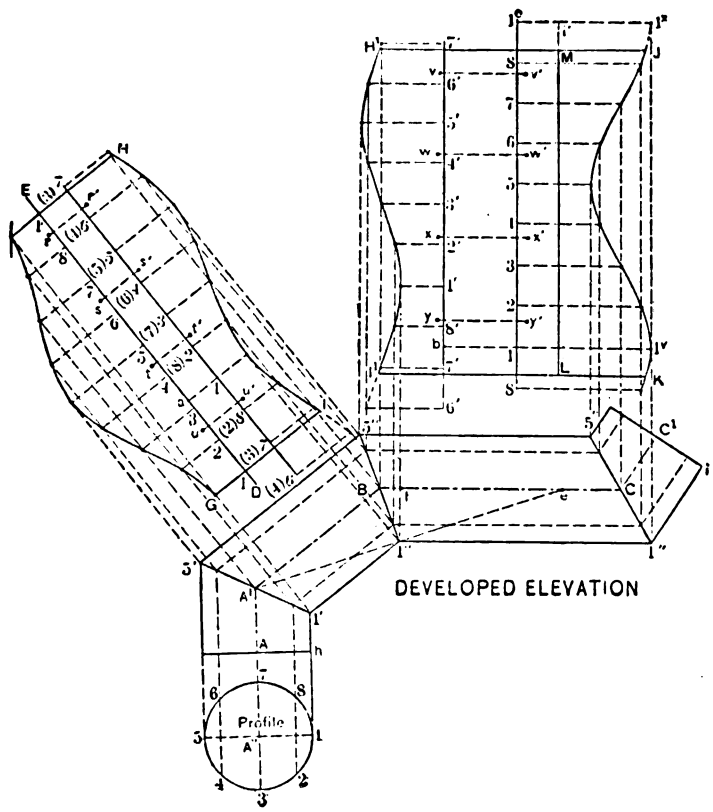

Fig. 179. Obtaining the Miter Lines and Patterns

It is now necessary to know how much the elbow B will turn on the elbow A^1, and how much the elbow C will turn upon the elbow B. To accomplish this another operation in projection is necessary, and is shown in Fig. 180, in which the center line A° A^x B C C^1 is a reproduction of A^2 A^1 B^1 C^1 C^2 in Fig. 177. Take a tracing of the plan A with the intersections 1 and 5 on same and place it directly under A^x A° in Fig. 180, as shown, the point 1 representing the shortest

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side of the lower arm of the elbow. Take a tracing of A^4 1′ A^3 5′ in Fig. 177, which is similar to A 1′ A^1 5′ in Fig. 179, and place it as shown by A^4 1′ A^3 5′ in Fig. 180, being careful to have the points A^4 and A^3 meet the horizontal lines drawn from the points A° and A^x, respectively. Directly below A^4 draw the plan A^1, which divide into the same number of spaces as the plan A, being careful to have 1 come directly below 1′.

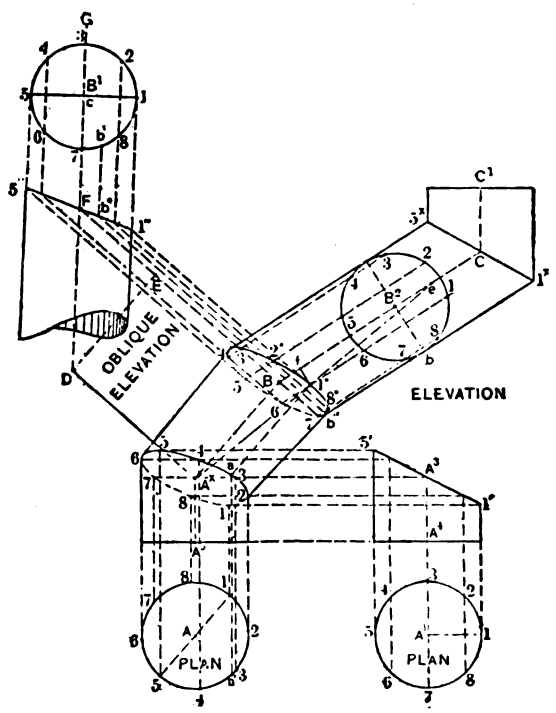

Fig. 180. Obtaining the Twist in Each Angle

From the various intersections in A^1 in Fig. 180 erect lines intersecting the miter line 1′ 5′, from which intersections, at right angles to A^3 A^4, draw lines, which intersect with lines drawn parallel to A^x A° from similar numbered intersections in A, resulting in the intersections 1 to 8 in A^x. Through these points trace the ellipse shown, which is the miter line in elevation. With the use of this miter line the amount can be obtained that the elbow B in Fig. 179 will turn upon the elbow A^1, there being in this problem a continuous seam. From the center line A^1 on the first miter line 5′ 1′ draw a line through the lowest point of the second miter line at 1″, which represents the line of the seam, and extend it until it intersects the center line B C at *e*. At right angles to B C, from 1″, draw the line 1″ *f*, intersecting B C at *f*. Now take the distances from B to *f* and *f* to *e* and place them on similar center line in Fig. 180, as shown. It must be remembered that Fig. 180 is a projection, and while B C in Fig. 180, in this case, shows the true length of B C in Fig. 179, it will not do so in most instances. If it does not, it is necessary to lay off the true distances B *f* and B *e* on the true length of B C, and then project the points properly on B C in Fig. 180. Draw a line from *e* to point A^x, which represents the similar point A^1 in Fig. 179. Then in Fig. 180, from *f*, at right angles to the line, not the projection of, B C, draw *f* 1°, which will intersect A^x *e* at 1°, the same relative position in elevation as 1″ in Fig. 179. From the point 1° in Fig. 180 parallel to the center line B A^x, draw a line intersecting the miter line shown by the ellipse at *a* between 3 and 4. From *a* drop a line into the plan intersecting the circle *a*′. The point *a*′ indicates the amount that the second elbow will be turned upon the lower one—that is, from 1 to *a*′.

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The next step is to find how much the upper elbow will be twisted upon the middle elbow. From 1° in elevation parallel to the center line B C draw 1° 1. Now, with any point on the line B C, as B^2, as center, and radius equal to A 1 in plan, describe the circle B^2, intersecting 1° 1 at 1. Then will this point 1 represent a' in plan and be numbered 1 in the profile B^2. Divide B^2 into eight equal parts. An operation in projection is now required to find the miter line of the middle elbow. Parallel and equal to A^x B draw the line D E, as shown. At right angles to D E erect E F, equal in distance to b B in plan in Fig. 177. Draw a line from F to D in Fig. 180, which equals A^3 B^3 in Fig. 177, or A^1 B in Fig. 179. Now take a tracing of 5′ 5″ B 1″ 1′ A^1 and place it in Fig. 180, placing the center line A^1 B upon the center line D F, and obtain the miter line 5″ 1″. Draw the profile B^1. Through c draw a horizontal line, as 1 5, and divide the circle also into eight equal parts, starting to number at the shortest side of the pipe. From the various intersections in B^1 in Fig. 180 draw lines parallel to G D, intersecting 1″ 5″. From these intersections, at right angles to A^x B, draw lines, which intersect with lines drawn parallel to B C in elevation from similar numbers in the profile B^2, resulting in the intersections 1° to 8°. Trace an ellipse through these points.

It will be noticed that a line drawn from 1″ in the oblique elevation meets the point 1° in elevation previously obtained on the line A^x e from f. As the upper angle of the elbow is the true angle similar to the upper angle in Fig. 179, then will the seam line or point 1‴ be represented in Fig. 180 by 1^x, and 1^x 5^x will be the true miter line, and no operation in projection will be necessary. If, however, this elbow was drawn so as not to show the true angle, then to find how much the upper elbow in Fig. 180 would turn upon the center one would require an operation similar to that used in connection with the turning of the center elbow on the lower one. Then the point b will represent the seam line of the elbow, 1‴ in Fig. 179, and the upper elbow will be turned upon the center one a distance equal to 1 b in the profile B^1 or B^2 in Fig. 180.

The final step is to develop the patterns, as shown in Fig. 179. At right angles to A^1 B draw the line D E, upon which place the stretchout of the plan A^2, as shown by similar figures on E D. At right angles to E D and through the small figures draw a line, which intersect with lines drawn at right angles to A^1 B from similar numbered intersections on the miter line 1′ 5′. Through points thus obtained trace a line, as shown by F G, which is the miter cut for the lower elbow. Now take the distance from 3 to a' in the plan A in Fig. 180 and place it in Fig. 179 on the line E D, between the points 3 and 4, as shown from 3 to a. Parallel to E D draw any line, as 6 7, at right angles to which from a draw a line intersect-

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ing the line 6 7 at 1. Then starting from 1 lay off similar stretchout as on E D, as shown from 1 to 7 and 1 to 6, allowing the spaces to project over the lines 1 and 1′ on E D. At right angles to 7 6, from the various intersections on same, draw lines, which intersect by lines drawn at right angles to A^1 B from similar numbered intersections on the miter line 1″ 5″. A line traced through points thus obtained, as shown by H I, will be the miter cut for the middle elbow. Extend the lines F 1′ and G 1 in the pattern, as shown, respectively, by F H and G I, intersecting the miter cut H I at H and I, respectively. Then will F G I H be the pattern for the piece A^1 B in elevation, with the upper miter cut H I in its proper position to give the middle elbow the required twist over the lower one.

If the piece A^1 B requires a joint in the middle and holes are to be punched before rolling, then mark off the holes, as many as required, as shown by *r*, *s*, *t* and *u*, and parallel to the lines of the pipes carry them across on the upper cut H I, as shown by *r′*, *s′*, *t′* and *u′*. Then when the pieces are rolled up and fitted hole over hole the elbows will be twisted in their proper position.

For the pattern for the lower arm of the first elbow take the distance *h* 1′ and place it in the pattern, as shown by G 1 and F 1′, and draw a line from 1 to 1′. Then will 1′ F G 1 be the pattern for A A^1 with the seam on the shortest side. H^1 7′ 7′ I^1 is a reproduction of H 7 7 I in the pattern for the second piece. For the opposite cut of the third piece proceed by a method similar to that by which the second piece was determined. The method of punching in this piece is shown by *v w x y* and *v′ w′ x′ y′*. For the pattern for the upper arm, C C^1, proceed as in the pattern for the first piece. In the patterns shown the seam will run along the bottom from *h* to *i* in a continuous line. Laps must be allowed.

PATTERNS FOR A FORGE HOOD

To obtain the patterns of a hood for a forge similar to that shown in Fig. 181, the hood is bolted to the forge at A and seamed at B and C. Proceed as follows:

The methods for obtaining the patterns are shown in Fig. 182, in which A B C D E F is the elevation of the hood, G being the plan view on E H, and M and N the plan views of F C and A B, respectively.

The lower part of the hood, shown by F C D E, will be developed first. Divide one half of the profile G into equal spaces, as shown from 1 to 7, and from the points 1 to 4, or as much as is taken up by the curve C D in elevation, erect vertical lines cutting the curve as shown from C to D. Establish an extra point *a′*,

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from which drop a vertical line intersecting the profile G at *a*. Extend the line E D as H J, and then, on it place the full girth of the profile G, as shown by similar figures on H J. At right angles to H J erect vertical lines, which intersect by lines drawn parallel to H J from corresponding intersections on the curve C D in elevation. A line traced through points thus obtained, as shown by L K 4 4, will be the desired pattern, to which edges must be allowed for seaming and riveting.

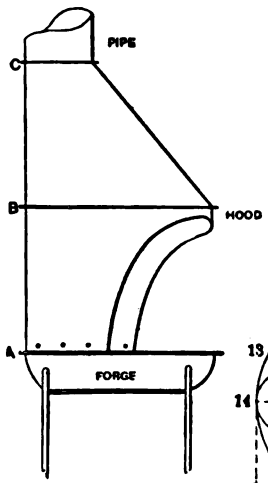

Fig. 181. View of Forge Hood

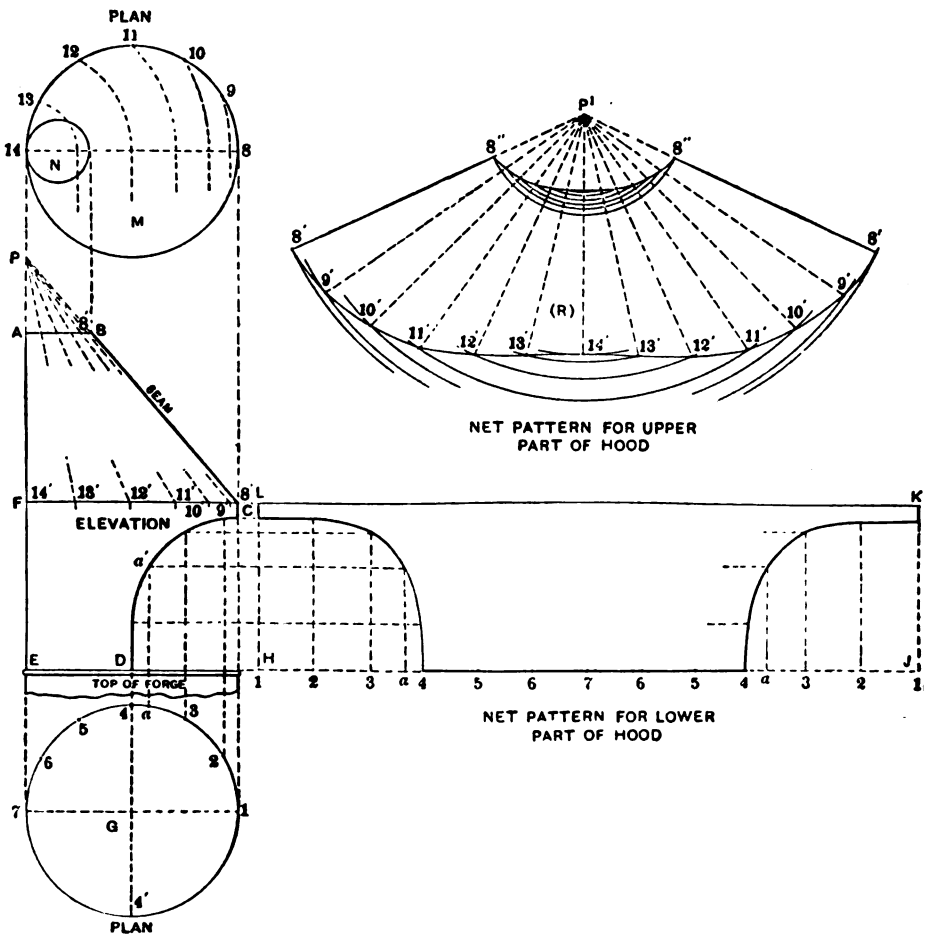

Fig. 182. Plan, Elevation and Patterns

The pattern for the upper part of the hood A B C F is obtained as follows: Extend F A and C B until they intersect at P. P is then the apex of a scalene cone, the apex shown in plan by 14. Divide the semicircle M into equal spaces, as shown from 8 to 14, and with 14 as center and radii equal to 14 13, 14 12, 14 11, 14 10 and 14 9, draw arcs intersecting the center line 8 14 as shown, from which points lines are carried vertically to the elevation, cutting the base of

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the cone F C at 8′, 9′, 10′ to 14′. From the various points 8′ to 14′ draw radial lines to P, cutting the line A B as shown.

These various radial lines give the true lengths or radii to develop the pattern shown by (R). Therefore, with P^1 as center and radii equal to P 14′ to P 8′ draw arcs in (R) as shown by similar numbers. Now set the dividers equal to one of the equal spaces in plan M, and starting from arc 14′ in (R) step to arc 13′, then to 12′ and so on until the arc 8′ has been intersected on both sides. From these points draw radial lines to P^1, which intersect by arcs having radii of similar numbers, obtained from P in the elevation, to various intersections on A B. For example, using P 8″ as radius, and P^1 in (R) as center, intersect the radial lines 8′ P^1 on both sides at 8″ 8″. Through points thus obtained trace the pattern shown by 8′ 8″, 8″ 8′, to which edges are allowed for seaming and riveting.

PATTERN FOR SHEET IRON FORGE HOOD

In Fig. 183 is shown a perspective view of a forge hood in which A is the forge hood, connected to the round smoke pipe at C and bolted to the forge at B. In developing this style hood, a lot of time and drawing can be saved by following the short, accurate rule given in the following two figures:

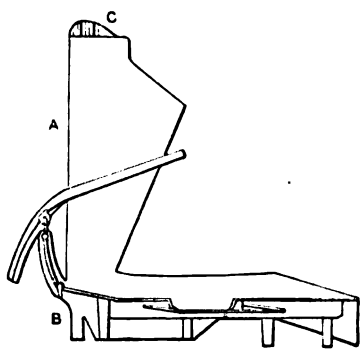

Fig. 183. View of Forge Hood

Let A B C D E in Fig. 184 be the side elevation of the forge hood, the plan of which on A B, is shown by F and the partial section on E D is shown by G H. Bisect both plans as shown by the dotted lines *a b* and *c d*. The pattern will be developed without the use of a plan, for if a plan was used it would be necessary to project a horizontal section into the plan from the line C D in elevation, which is to be avoided when both halves of the article are symmetrical.

The short rule is shown in Fig. 185, in which 1, 5, 6, 9″ 13 is a reproduction of A B C D E in Fig. 184. Take a tracing of the half plan *a b* F and *c d* G and place it in Fig. 185 as shown by *a* and *c*, respectively.

Obtain a true section on the line 6 9″, as follows: Draw the perpendicular 9″ 9 equal to 9″ 9′, and at pleasure draw any desired sweep or shape as shown by 6 8 9. It should be understood that this shape can be made at will, so long as the distance 9″ 9 is equal to 9″ 9′. Divide the curves in the semisections *b* and *c*

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into equal spaces (two in each) and divide the semisection *a* into as many spaces as contained in *b* and *c* (in this case four). Number these points 1 to 5 in *a*, 6 to 9 in *b* and 9′ to 13 in *c*. At right angles to 1 5, 6 9″ and 9″ 13 and from the various divisions in the semisections *a*, *b* and *c* draw lines intersecting respectively the lines 1 5, 6 9″ and 9″ 13, as shown by similar numbers. Connect the various points by dotted and solid lines, as shown.

The next step is to obtain the true lengths of the solid and dotted lines shown in A, as shown respectively in diagrams B and C. In A, 1 13 and 5 6 show their true lengths. To obtain the true length of 2′ 11′ in A, take that distance and place

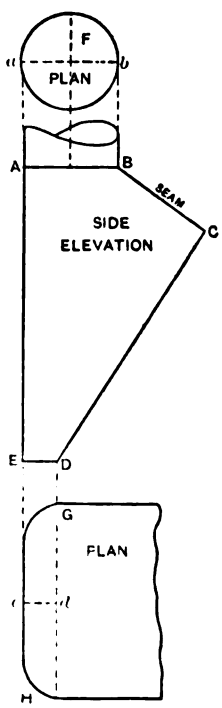

Fig. 184
Detail of Forge Hood

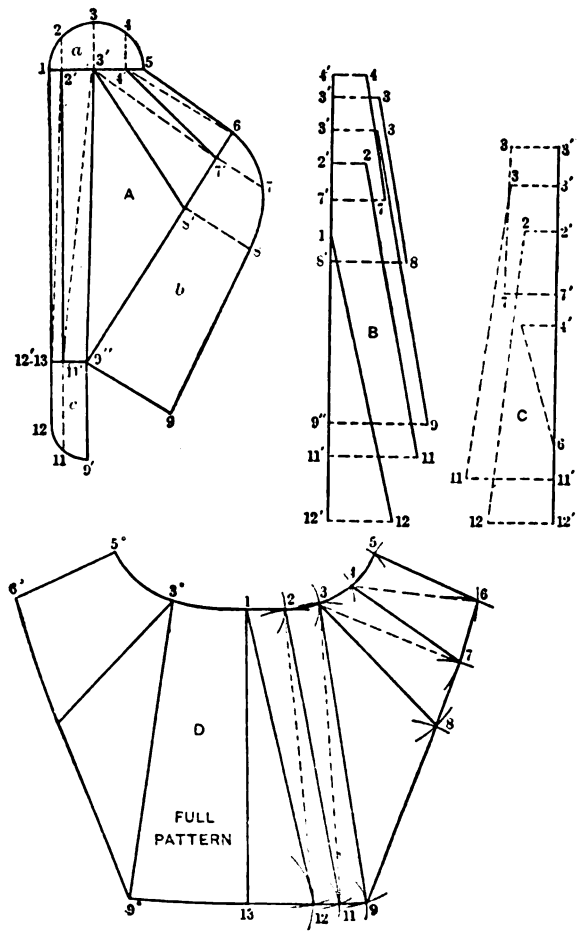

Fig. 185. Developing Pattern for Forge Hood

it as shown by 2′ 11′ in B. Erect the perpendiculars 2′ 2 and 11′ 11, equal respectively to similar numbers in the semisections *a* and *c* in A. Then 2 11 in B is the true length of that numbered line in A. In this manner all of the true lengths of the solid lines are obtained in B and that of the dotted lines in C, as shown by similar numbers.

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For the pattern in which the seam is to come on 5 6 in A, proceed as shown in D. Draw the vertical line 1 13 equal to 1 13 in A. With 13 12 in *c* as radius and 13 in D as center draw the arc 12, which intersect by an arc struck from 1 as center and 1 12 in B as radius. Now with radius equal to 1 2 in *a* and 1 in D as center draw the arc 2, which intersect by an arc struck from 12 as center and 12 2 in C as radius. With radius equal to 12 11 in *c* and 12 in D as center, draw the arc 11, which intersect by an arc struck from 2 as center and 2 11 in B as radius. Proceed in this manner, using alternately the divisions in *a*, the true lengths in C, the divisions in *c* and the true lengths in B until the line 3 9 in D is obtained. With radius equal to 9 8 in *b* and 9 in D as center, draw the arc 8, which intersect by an arc struck from 3 as center and 3 8 in B as radius. Proceed as before, using alternately first the divisions in *b*, the true lengths in C, the divisions in *a* and the true lengths in B, until the line 5 6 in D is obtained, being measured from 5 6 in A. Then 1 5 6 9 13 in D is the half pattern, and when traced opposite 1 13, as shown by 3° 5° 6° 9°, will complete the full pattern, to which edges must be allowed for seaming and riveting.

PATTERN FOR THREE-WAY BRANCH

The branch for which the pattern is to be developed is shown in Fig. 186, where A is the inlet, and B, C and D the three outlets or branches. In Fig. 187 is shown the plan and elevation of the three-way branch, the lines of the joints being indicated by I J and J K. The opening on the line A B is shown by L M N O, on C D by P R S T, and on E F by U V W X. The section on H G is represented by Y Z Y^1 Z^1, while A^1 B^1 C^1 D^1 E^1 F^1 are plan views of the three openings. In this problem the axial lines lie in one plane; if the reader desires a solution of a problem in which the axial lines of the two branches radiate from the center of the large or center pipe, he is referred to page 391 of "The New Metal Worker Pattern Book."

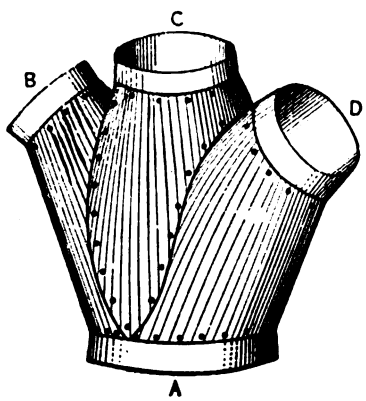

Fig. 186. The Finished Branch

Draw the line in plan from H^1 to Z to J^1, and from K^1 to Z^1 to L^1, which will represent the plan view on each side, taken on the dotted lines N^1 J W^1 in elevation. Knowing the hight and the width at the bottom, the shape can be established at pleasure, as in Fig. 188, where I J equals I J of the elevation, Fig. 187.

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At right angles to I J in Fig. 188 draw the line Z Z^1 through J, making J Z^1 and J Z equal to J G or J H in elevation, Fig. 187, or equal to & Z or & Z^1 in plan. Through the points Z I Z^1 in Fig. 188 draw any desired elliptical figure, as shown, which will represent a true section on I J or J K in elevation, Fig. 187.

Only one pattern will be required, also a separate pattern for the center branch, both of which will be developed by triangulation.

To obtain the measurements for the sections for the center branch proceed as shown in Fig. 189, where 14 4 5 9 5′ 4′ is a reproduction of O^1 C I J K D in elevation, Fig. 187. As the four quarters of this center branch are alike, only one quarter pattern will be developed; then, if desired, the quarter patterns can be joined together, forming one pattern. Take a tracing of the quarter profile T Q P and place it as shown by 4 14 1 in Fig. 189. In similar manner take a tracing of the section I J Z^1 in Fig. 188 and place it as shown by 5 9 8 in Fig. 189. Divide the profile 1 4 into equal spaces, and in similar manner divide the profile 5 8 into the same number of spaces. In practice more spaces should be employed than are here shown, for the closer the divisions are made the more accurate will be the pattern.

At right angles to 4 4′ and 5 9 and from intersections on the curve 1 4 and 5 8 draw lines as shown, intersecting the lines 4 4′ and 5 9 at 12 and 13, and 10 and 11 respectively. Draw solid lines from 12 to 11, 13 to 10, 14 to 9, and dotted lines from 12 to 5, 13 to 11 and 14 to 10. Then will these solid and dotted lines represent the bases of sections which will be constructed, and the altitudes of which will be equal to the hights shown in the profiles. Thus in Fig. 190 draw the line 9 14, equal to 9 14 in Fig. 189; at right angles to 9 14 in Fig. 190 draw the lines 9 8 and 14 1′, equal to 9 8 and 14 1 in Fig. 189. Draw a line from 8 to 1 in Fig. 190, which represents the actual distance on the finished article on similar line in Fig. 189. Proceed in precisely the same manner for the balance of the sections.

For the sections on dotted lines in Fig. 189 proceed in the same manner as described in Fig. 190. For example, take the distance 10 14 in Fig. 189 and place it as shown by 10 14 in Fig. 191. At right angles to 10 14 from points 10 14 draw the lines 10 7 and 14 1, equal to 10 7 and 14 1 in Fig. 189. Draw a line from 7 to 1 in Fig. 191, which will represent the actual distance on the finished article on similar line in Fig. 189. Having now the necessary measurements in Figs. 189, 190 and 191, the pattern is obtained in Fig. 192 as follows:

Draw any vertical line, as 1 8 in Fig. 192 equal to 1 8 in Fig. 190. With 8 7 in Fig. 189 as radius and 8 in Fig. 192 as center describe the arc 7. Then, with 1 7 in Fig. 191 as radius and 1 in Fig. 192 as center describe an arc intersecting

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the arc 7. Again using 1 as center and 1 2 in Fig. 189 as radius describe the arc 2 in Fig. 192. Then, using 2 7 as radius in Fig. 190, and 7 as center in Fig. 192, describe an arc intersecting the arc 2. Proceed in this manner, using, alternately, first the divisions in the profile 5 8 of Fig. 189, then the length of the slant lines in Fig. 191, the divisions in the profile 1 4 of Fig. 189, then the length of the slant lines in Fig. 190, until all the points in the pattern in Fig. 192 have been obtained. Trace a line, as shown by 1 4 5 8, which will be one quarter of the pattern.

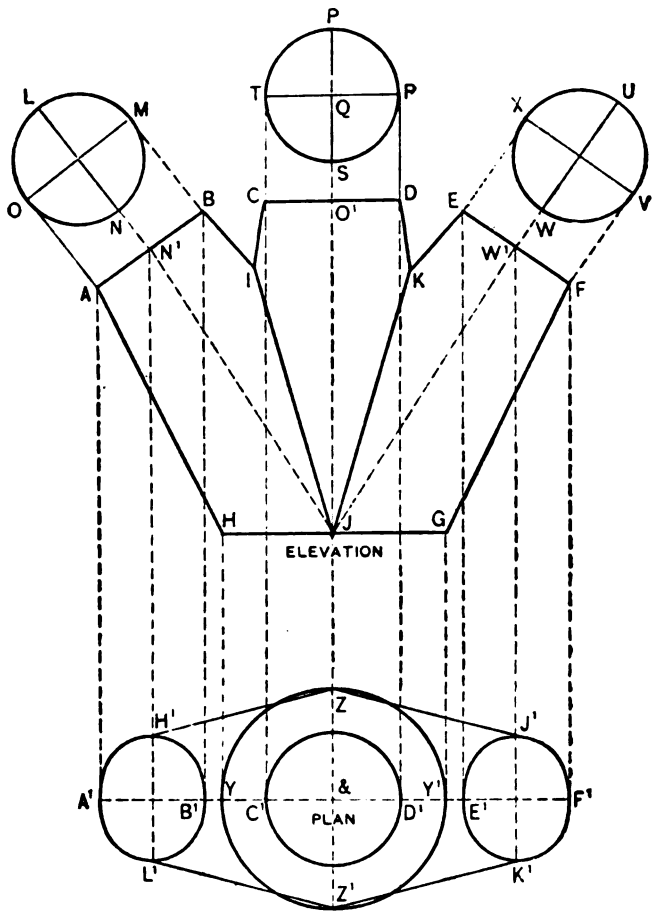

Fig. 187. Plan and Elevation of the Branch

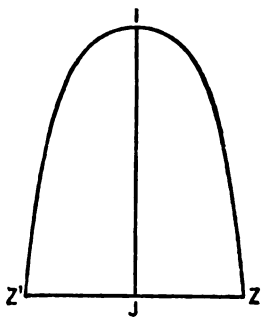

Fig. 188. Arbitrary Section of Branch on I J of Fig. 187

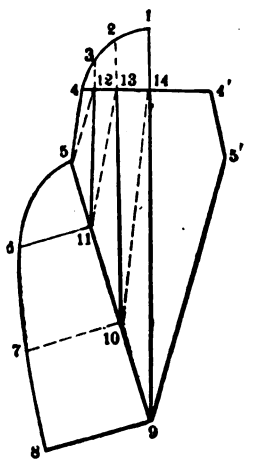

Fig. 189. Obtaining the Base Lines for Diagrams of Triangles

If the pattern is desired in one piece, then trace opposite the lines 1 8, 4′ 5, and 1′ 8′. Then will 4 4″ 5″ 8′ 8 5 4 be the full pattern for the center branch.

As the two side branches are alike one pattern will answer for the two. In Fig. 193 let 1 7 8 12 16 be a reproduction of E F G J K in elevation, Fig. 187. Take a tracing, shown by X U V in elevation, Fig. 187, and place it as shown by 7 4 1 of Fig. 193. In similar manner take a tracing of I J Z′ in Fig. 188 and

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Y^1 Z^1 & in plan in Fig. 187 and place them as shown by 8 12 11 and 16 13 12 respectively in Fig. 193. Divide the two lower profiles 8 11 and 13 16 each into three equal spaces, and the upper profiles 1 7 into six equal spaces, as shown by

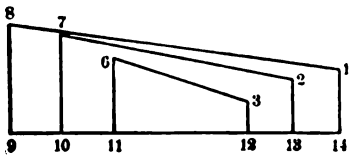

Fig. 190. Diagram of Solid Lines of Fig. 189

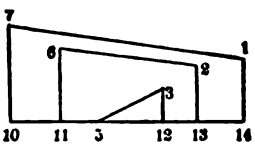

Fig. 191. Diagram of Dotted Lines of Fig. 189

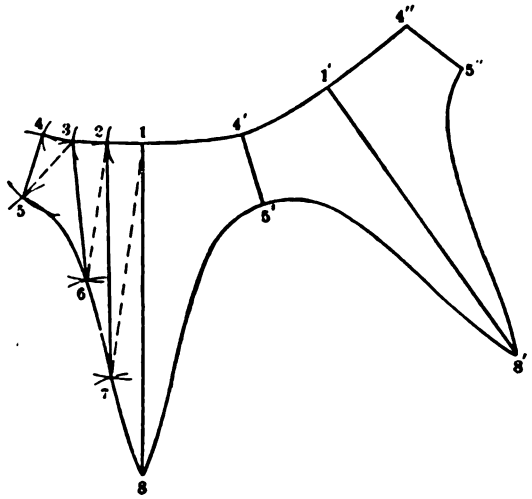

Fig. 192. Method of Developing Pattern from the Diagram of Triangles for Fig. 189

the small figures 1 to 16. At right angles to 1 7, 8 12 and 12 16, and from the small figures in the profiles, draw lines intersecting the lines 1 7, 8 12 and 12 16 respectively, at points 24, 23, 22, 21, 20, 19, 18 and 17. Draw solid lines from 20 to 21, 19 to 22, 12 to 23, 18 to 24 and 17 to 25, and dotted lines from 8 to 21, 20

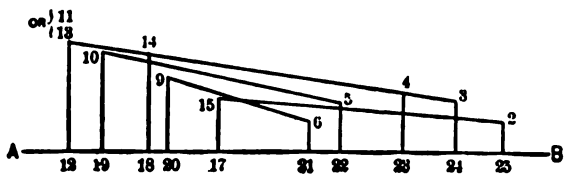

Fig. 194. Diagram of Solid Lines of Fig. 193

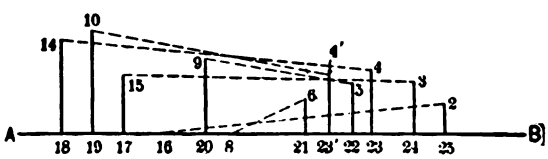

Fig. 195. Diagram of Dotted Lines of Fig. 193

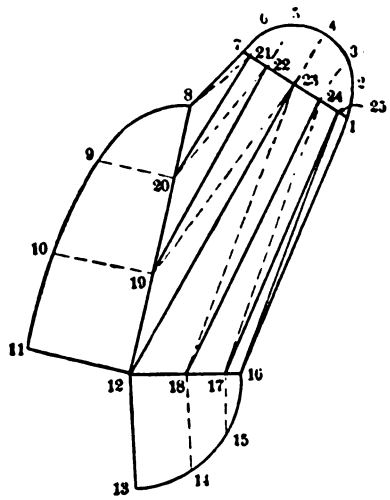

Fig. 193. Obtaining the Base Lines for Diagrams of Triangles

to 22, 19 to 23, 18 to 23, 17 to 24 and 16 to 25. Then will these solid and dotted lines represent the bases of sections, the altitudes or hights of which will be obtained from the vertical lines in the three profiles.

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In Fig. 194 are shown the sections on the solid lines in Fig. 193, and in Fig. 195 the sections on dotted lines in Fig. 193. These sections are obtained in precisely the same manner as was described in connection with Figs. 190 and 191, and will not be further explained here. Similar numbers in Figs. 194 and 195 correspond to similar numbers in Fig. 193.

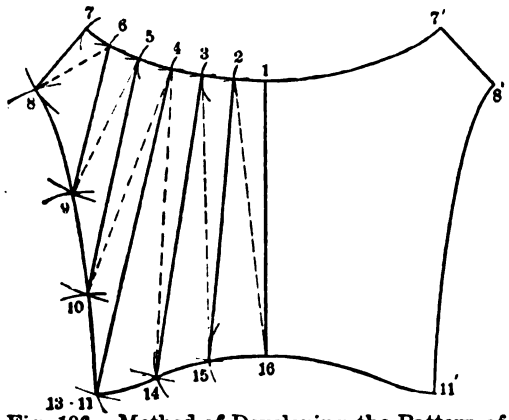

Fig. 196. Method of Developing the Pattern of Side Arms from the Diagram of Triangles

In Fig. 196 is shown the pattern shape for the side branch shown in Figs. 187 and 193, and is obtained in the same manner as described in connection with Fig. 192. First draw any vertical line, as 1 16 in Fig. 196, equal to 1 16 in Fig. 193. Then use alternately as radii first the spaces in the profile 1 7 in Fig. 193, then the length of the slant lines in Fig. 195, the spaces in the profile 13 16 in Fig. 193, then the length of the slant lines in Fig. 194, until the line 4 11 or 13 in pattern in Fig. 196 has been obtained. Starting from the point 13 11 in pattern, use alternately as radii first the divisions in the profile 11 8 in Fig. 193, then the length of the slant lines in Fig. 195, the divisions in the profile from 4 to 7 in Fig. 193, then the length of the slant lines in Fig. 194, the line 7 8 in the pattern in Fig. 196 being obtained from 7 8 in Fig. 193. A line traced through points thus obtained in Fig. 196, as shown by 1 7 8 11 13 16, will be the half pattern. Trace the other half opposite line 1 16, which will complete the full pattern for side branches. Laps to be allowed for riveting or seaming.

PATTERNS FOR TAPERING FORK

In the following method of how to lay out the patterns for the tapering fork shown in Fig. 197, A B C D E is the elevation of the fork, F being the diameter through E, and H and G the sections through A and D. The patterns for the pieces A and D are obtained the same as for any elbow piece, while E is simply a straight piece of pipe. The two forks B and C are of different sizes, but their patterns are developed by the same principles, the section on *a b* being the same in both forks. Similarly, if two or more pieces were used for the elbow or if the pipes H and G had their axis parallel with the axis of pipe F.

In Fig. 198 C D is an enlarged reproduction of C D in Fig. 197. Construct the half sections on 1″ 7″ and 1 7 by the usual method, as shown. Then, with

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11′ in C as center, describe the semicircle 8 11 11″. At pleasure draw any desired curve, as 11″ 12 14, representing the half section on *a b* in Fig. 197. Divide the profiles L, F and J into the number of spaces shown, and draw perpendiculars to

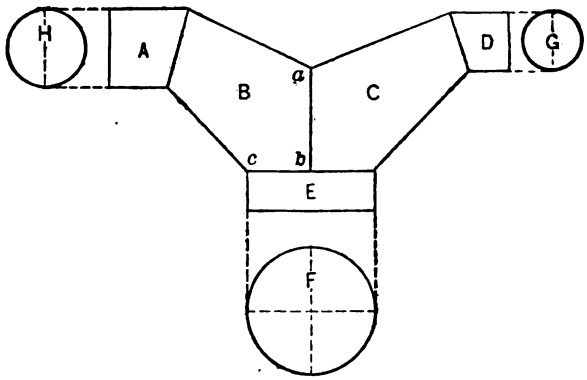

Fig. 197. The Fork and Elbows

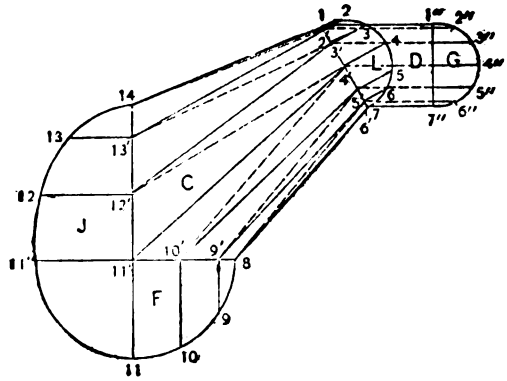

Fig. 198. Obtaining Measurements for Sections

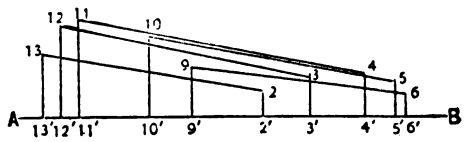

Fig. 199. Sections on Solid Lines in Fig. 198

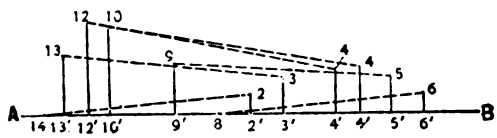

Fig. 200. Sections on Dotted Lines in Fig. 198

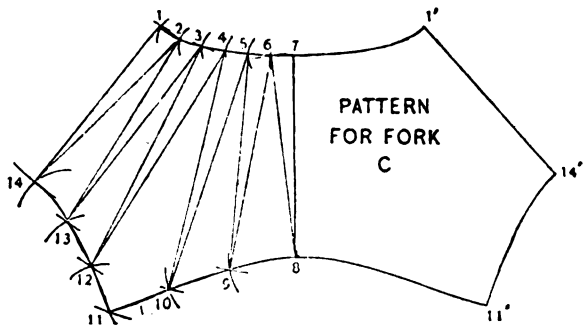

Fig. 201. The Pattern Shape

the base lines. From these points draw the solid and dotted lines shown. These represent the bases, and the various lines in the profiles L, F, J the altitudes of the sections which are constructed in Figs. 199 and 200 by the usual method. This being completed, proceed to lay out the pattern, as shown in Fig. 201.

REDUCING OFFSET IN PIPE WORK

In the illustration Fig. 202, is shown to what use a reducer is put. The reducer is shown by A and joins the large and small pipes at *b* and *a*. The joints at *a* and *b* are on horizontal lines, each being locked as shown at *e*, or they can be riveted, when heavy metal is used. The reducer can be developed the same as a scalene cone as shown. All unnecessary drawings are omitted, using only such lines as are actually required.

Draw the side view of the offset with the proper projection, hight and top and

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bottom diameters, as shown by 1″ 5″ 5 1, Fig. 203. Extend the lines 1 1″ and 5 5″ until they intersect at A. Now extend the base line 1 5 and intersect it by a line drawn from the apex A at right angles to 1 5 at A^1. Draw the one half section on 1 5 as shown by 1 3 5, which divide into equal spaces as shown. With A^1 as center and radii equal to A^1 4, A^1 3, and A^1 2, draw arcs intersecting the base line 1 5 at 2′ 3′ and 4′, from which points draw lines to the apex A intersecting the upper line 1″ 5″ at 2″, 3″ and 4″.

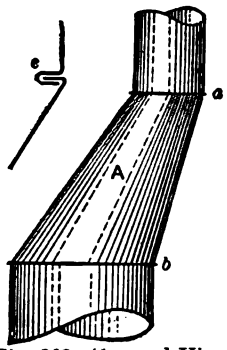

Fig. 202. General View of Reducer

Using A as center, with radii equal to A 1, A 2′, A 3′, A 4′ and A 5, draw arcs as shown. Set the dividers equal to one of the spaces in the half section and, starting on arc 5, or wherever

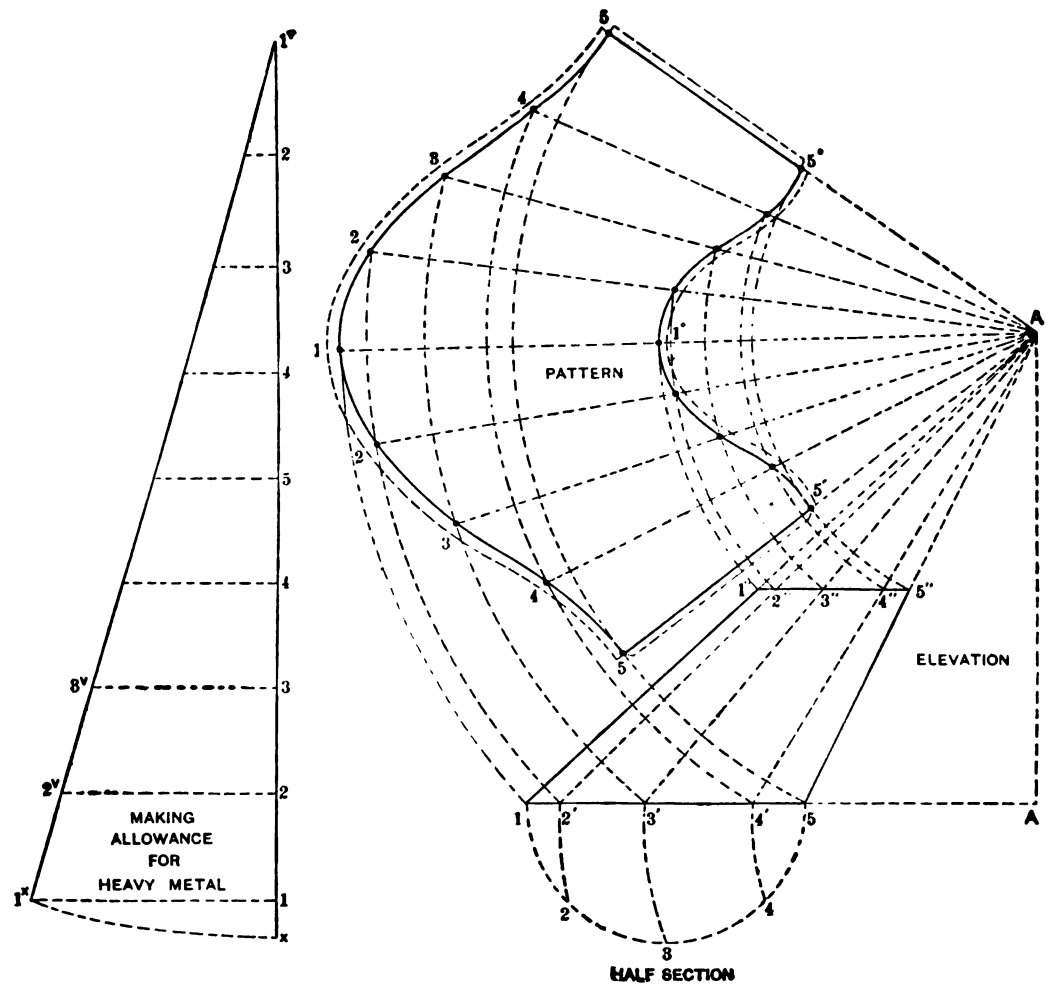

Fig. 203. Method of Developing Pattern for Offset

it is desired to have the seam, step from one arc to another as shown by 5 to 4 to 3 to 2 to 1, and then again to 5. From these small figures draw radial lines to

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A, which intersect at 5° to 1° to 5° by arcs, struck from the center A, with radii equal to the various divisions on the line 1″ 5″. A line traced through these points as shown by 5 5° 1° 5° 5 1 5 will be the net pattern for the reducer.

Laps are allowed for seaming or riveting as shown by the dotted lines. If the reducer is made from heavy metal (which is usually riveted), allowance must be made for the thickness of the metal used, as follows: Take twice the girth of the half section and place it on the vertical line 1 X as shown from 1^v to 5 to 1. Assuming that the thickness of the metal in use is $\frac{1}{8}$ in., then take $7 \times \frac{1}{8}$ or seven times the thickness of the metal in use and place it as shown from 1 to X. Using 1^v as center and 1^v X as radius, draw an arc, which intersect by the perpendicular drawn from 1 at 1^x. Draw a line from 1^x to 1^v, and erect perpendiculars from points 2, 3, etc., thus obtaining 2^v, 3^v, etc. Then, instead of using the spaces in the half section to step off in the pattern as we have just done, one of the spaces on the slant line 1^x 1^v is used. This gives the necessary allowance to the girth on 5 1 5 in the pattern, after which proceed as before in obtaining the upper cut, 5° 1° 5°. This same rule also applies to making the necessary allowance for the thickness of the metal in the straight pipes *a* and *b* of the perspective sketch, Fig. 202.

RECTANGULAR AND OVAL PIPE FORK

The following is a method of finding miter lines of a rectangle running into an oval that is offset two ways, the opening to have same capacity at both miter connections. In this connection it may be proper to say that no matter what size the opening is at either inlet or outlet, or what form the article has, the principles hereinafter described are applicable to any case. In Fig. 204 let A B C D E F G be the elevation of the offset, the seams being at G A, E H and B C. Let I J K L be the plan of the rectangular base on the line A B in elevation, and M N O P the section of the oval on G F of one of the arms, while D C on the opposite arm has the same section. Though the plan is not necessary, so far as the pattern is concerned, the method of drawing it is given so that the student will understand its construction, if the occasion should arise. Bisect the short sides of the rectangle I L and J K in plan at points O^1 and O^2, through which draw indefinitely the line M^1 M^2.

Now, at right angles to A B in elevation, and from points F and G, drop lines intersecting the line M^1 M^2 in plan at points M^1 and O^1. At right angles to G F in elevation extend the center line N P in oval section, meeting G F at R. From R at right angles to A B drop a line indefinitely into plan, as R P^1. Take the

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distance X N or X P in oval section, and, measuring from the center line M^1 M^2 in plan, place the distance on the line P^1 R, as shown by P^1 and N^1. Then through M^1 N^1 O^1 P^1 draw the figure shown. From R in elevation draw lines to

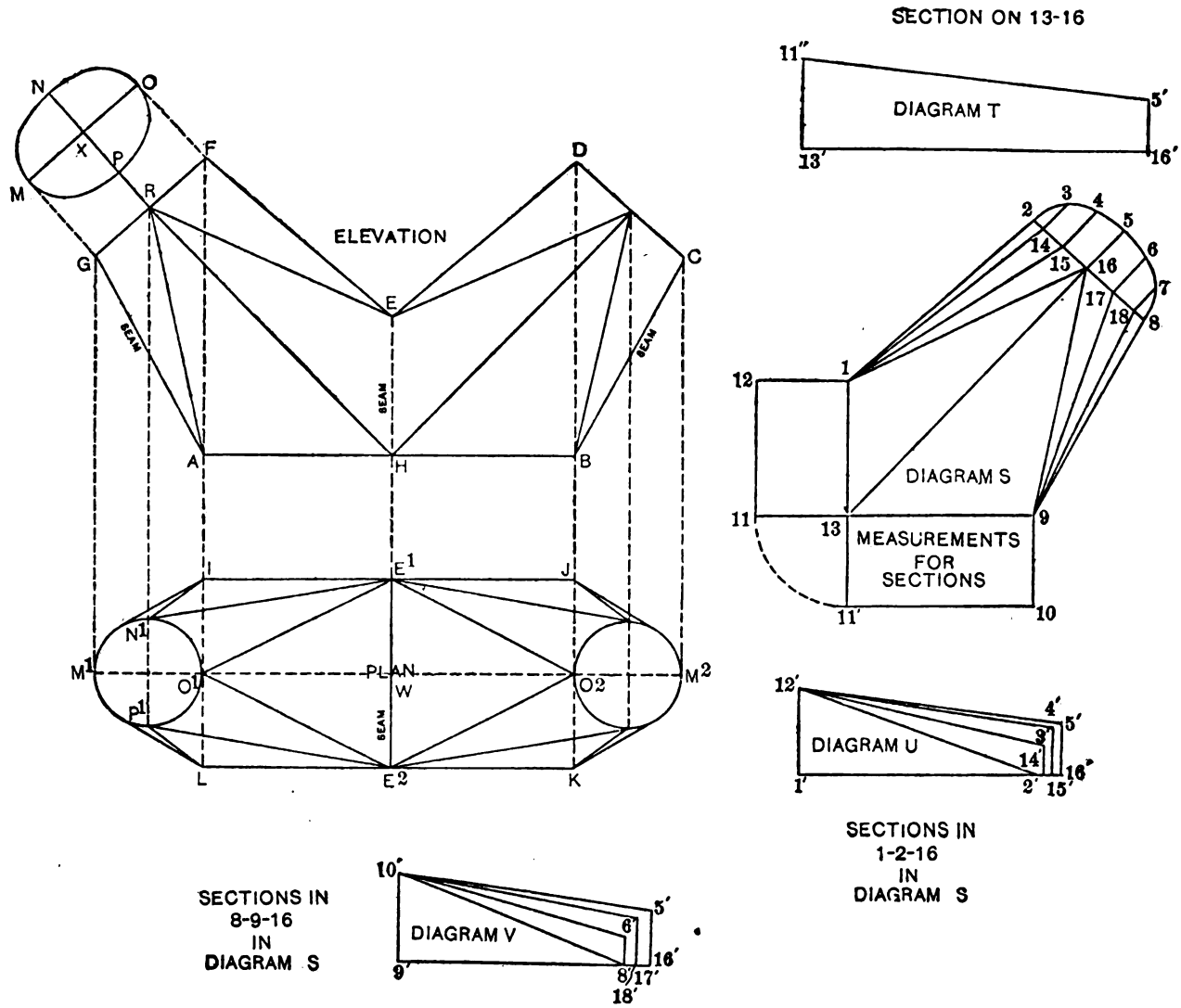

Fig. 204. Plan, Elevation, Measurements for Sections and Diagrams

A, H and E, representing the lines of the transition. In similar manner connect similar lines in plan. As the two arms are symmetrical, trace similar lines opposite in plan and elevation. Then will M^1 N^1 O^1 P^1 L E^2 K O^2 M^2 J E^1 I be the plan of the offset when viewed from the top.

As the pattern for one arm will answer for both, in diagram S let 1 2 8 9 13 be a reproduction of E D C B H in elevation. Take a tracing of M N O in the oval section and place it in diagram S, as shown by 2 5 8. In similar manner take

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a tracing of E^1 J O^2 W in plan and place it as shown by 13 9 10 11′ in diagram S. It will now be necessary to obtain a section on E H in elevation, or 1 13 in diagram S; therefore from 1 and 13 and at right angles to 1 13 draw the lines 1 12 and 3 11, equal in length to 13 11′, as shown by the quarter circle, which is the one half width, E^1 W, in plan. Draw a line from 12 to 11 in diagram S. Then will 1 13 11 12 be the half section on E H in elevation or W E^1 in plan. Divide the half oval 2 5 8 in diagram S into equal spaces, as shown by the small figures 2 3 4 5 6 7 and 8, from which at right angles to 2 8 draw lines intersecting 2 8 at 14 15 16 17 and 18. From points 2 14 15 and 16 draw lines to point 1. From 16 draw a line to 13, and from points 16 17 18 and 8 draw lines to 9. Then will these lines represent the bases and the three sections on 2 8, 1 13 and 13 9 the altitudes, with which to construct the sections used in obtaining the pattern.

In diagram T draw any line, as 13′ 16′, equal to 13 16 in diagram S, and at right angles to 13′ 16′ in T draw the line 13′ 11″ and 16′ 5′, equal to 13 11 and 16 5 in diagram S. Draw the line 11″ 5′ in T, which will be the actual distance on the finished article on 13 16 in S. In similar manner draw any line, as 1′ 16′ in diagram U, upon which place the various lengths shown in diagram S by 1 2, 14, 15 and 16, as shown in diagram U by 1′ 2′, 14′ 15′ and 16′. At right angles to 1′, and from points 1′ 14′ 15′ and 16′, draw the lines 1′ 12′, 14′ 3′, 15′ 4′ and 16′ 5′, equal in length to 1 12, 14 3, 15 4 and 16 5 respectively in diagram S. Then draw lines in diagram U, as shown by 12′ 2′, 12′ 3′, 12′ 4′ and 12′ 5′, which will represent the actual distances on lines having similar numbers in S. Proceed in precisely the same manner for sections in 8 9 16, as shown in diagram V by similar figures.

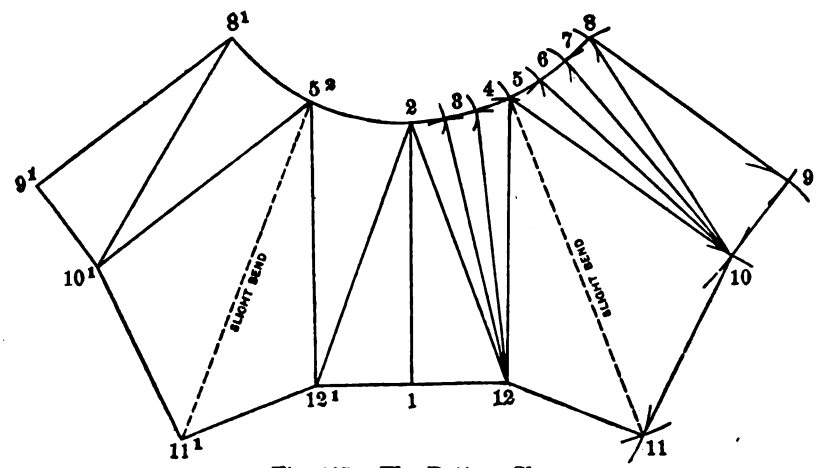

Fig. 205. The Pattern Shape

For the pattern proceed as follows: Draw any vertical line in Fig. 205, as 1 2, equal to 1 2 in diagram S in Fig. 204. Take the distance from 1 to 12 and place it from 1 to 12 in Fig. 205 at right angles to 2 1. Draw the line from 2 to 12, which will equal 2′ 12′ in diagram U in Fig. 204. Now with radii equal to 12′ 3′, 12′ 4′ and 12′ 5′, and with 12 in Fig. 205 as center, describe arcs, as shown by

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3 4 and 5. Set the compasses equal to the spaces into which the half oval in diagram S in Fig. 204 is divided, as shown by 3 4 and 5, and starting at 2 in

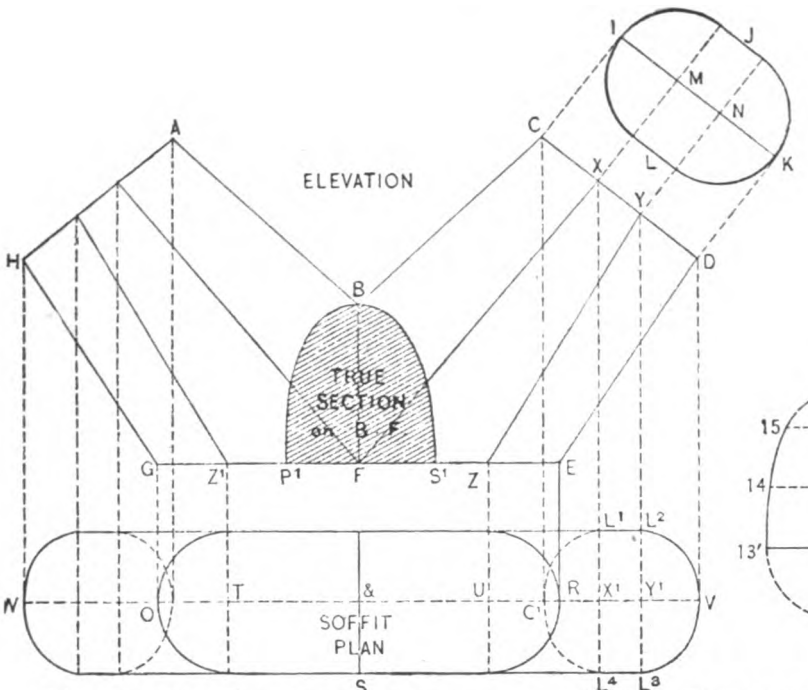

Fig. 206. Plan, Elevation and Sections

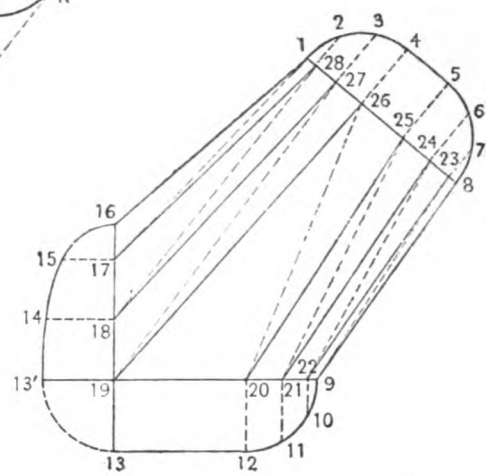

Fig. 207. Diagram for Obtaining Measurements for Sections

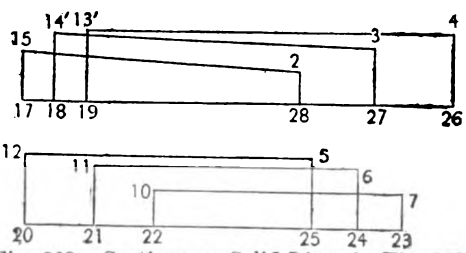

Fig. 208. Sections on Solid Lines in Fig. 207

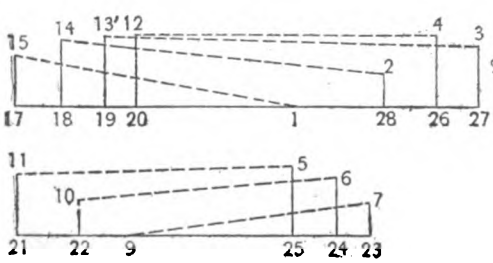

Fig. 209. Sections on Dotted Lines in Fig. 207

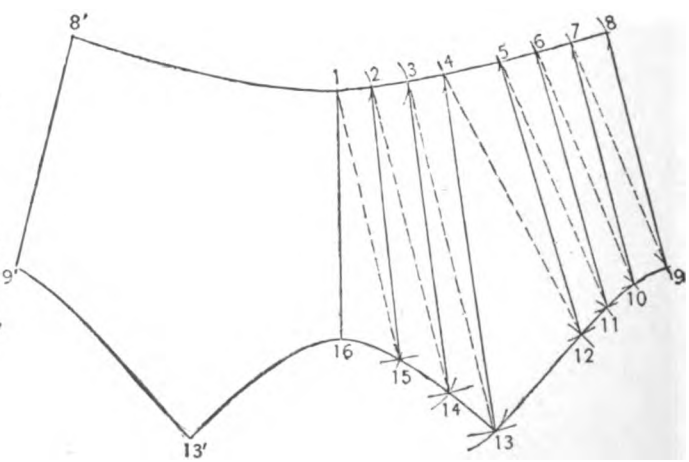

Fig. 210. The Pattern Shape for One Arm

Fig. 205 intersect the arc 3, then use 3 as center and intersect the arc 4, then 4 as center and intersect 5 and draw a line from 5 to 12. With 12 as center, and 12 11

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in S in Fig. 204 as radius describe the arc 11 in Fig. 205. Then with 5 as center, and 5′ 11″ in diagram T in Fig. 204 as radius, intersect the arc 11 in Fig. 205, as shown.

Next, using 11 as center, and 11′ 10 in S in Fig. 204 as radius, describe the arc 10 in Fig. 205, which intersect with an arc struck from 5 as center, and 5′ 10′ in diagram V in Fig. 204 as radius.

With radii equal to 10′ 6′, 10′ 7′ and 10′ 8′, and 10 in Fig. 205 as center, describe the arcs 6 7 and 8, which intersect with divisions equal to 6 7 and 8 in the half oval in S in Fig. 204. With 8 9 as radius, and 8 in Fig. 205 as center, describe the arc 9, which intersect with an arc struck from 10 as center, with a radius equal to 10 9 in S in Fig. 204. Trace a line through intersections thus obtained in Fig. 205, then will 1 2 5 8 9 10 11 12 be the half pattern. Trace the other half opposite the line 1 2, then will 8^1 5^1 2 5 8 9 10 11 12 1 12^1 11^1 10^1 9^1 be the full patttern.

In Fig. 206 is shown a similar fork, excepting that the section of the large pipe is oval, or rather rectangular with semicircular ends. The principles of developing the patterns are identical to the foregoing and as shown in Figs. 207, 208, 209 and 210.

FINDING THE TRUE ANGLE IN A FLARING OBJECT

To find the true angle between the flaring sides of an irregular hopper, proceed as follows: In the illustration, Fig. 211, A B C D represents the base of the hopper and E F G H the top. It is now desired to find the true angle between the sides E F B A and G F B C, which join on the hip line B F. Draw *a c* at right angles to the hip line F B in plan. Then construct an oblique elevation on F B in plan in which the true length of one of the hips will be shown, as follows: Parallel to F B draw F^1 B^1, which intersect by two lines drawn from F and B in plan at right angles to F B. Extend F F^1 to K, making F^1 K equal to the hight of the hopper in elevations. Draw K B^1, which is the true length of the hip. At right angles to F B extend *c a*, meeting F^1 B^1 at *b′*. From this point, at right angles to K B^1, draw *b′ e*. Through *b′*,

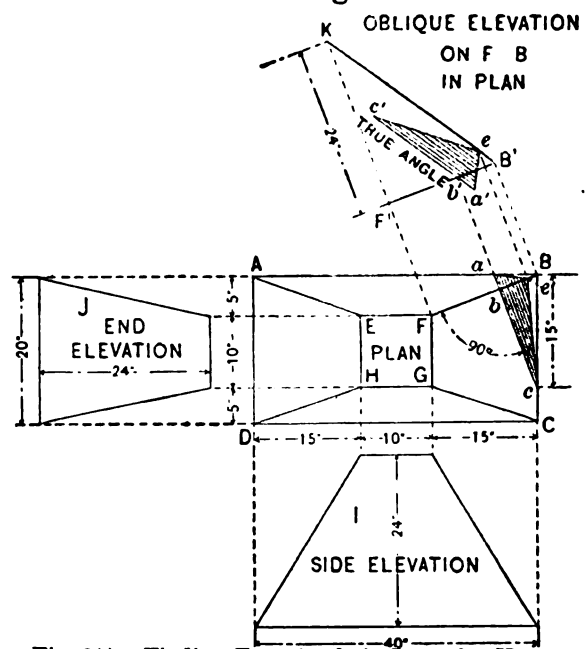

Fig. 211. Finding True Angle in Irregular Hopper

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parallel to K B^1, draw a' c', making b' a' and b' c' equal respectively to b a and b c in plan. Connect the points v' to e to c'. Then will the shaded portion a' e c' be the true angle between the sides of the hopper a and c at right angles to the hip line in plan and oblique elevation. e' in plan is obtained by dropping a line parallel to c b' from e, and a e' c in plan is the horizontal projection of the true angle, but it is not necessary to find this in practice.

SOME SHORT RULES FOR DEVELOPING PATTERNS

Fig. 212 shows an elbow at any angle, the rise of the miter line of which is equal to a b and its section is a rectangle, as shown by A. To obtain this pattern by

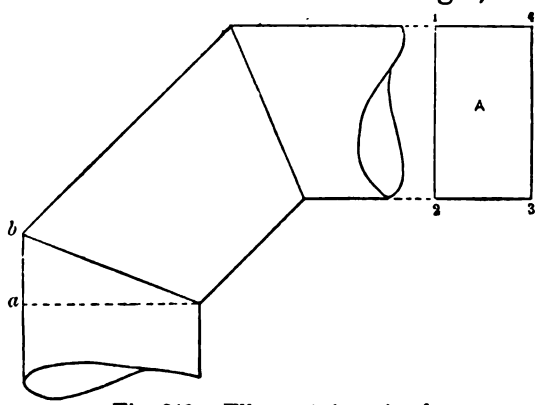

Fig. 212. Elbow at Any Angle

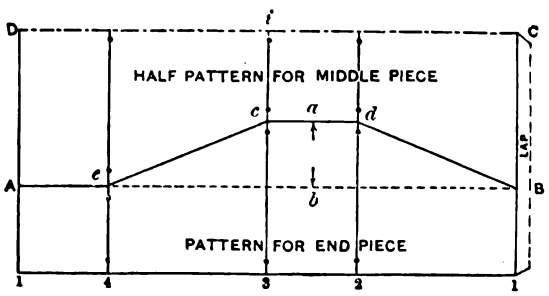

Fig. 213. Pattern for Elbow Shown in Fig. 212

the short rule take the girth of A and place it on the proper size sheet of metal, as shown from 1 to 1 in Fig. 213, the seam in this case to come on the corner 1 in

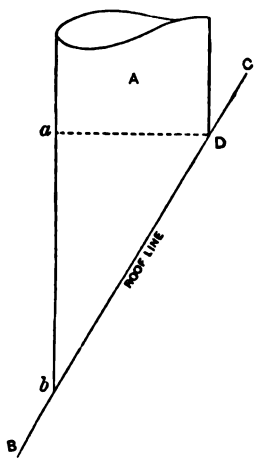

Fig. 214. Cylinder on Inclined Roof

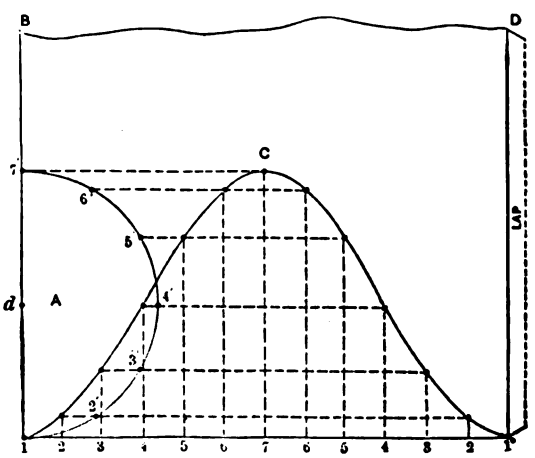

Fig. 215. Pattern for Cylinder on Inclined Roof

A in Fig. 212. Make 1 A and 1 B in Fig. 214 equal to the length of the end piece on the throat side and draw a line from A to B. Take the rise of the miter

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line *a b* in Fig. 212 and place it, as shown from *b* to *a* in Fig. 213, and through *a* draw the horizontal line *c d*. A *e c d* B is then the desired cut. Take the distance A 1 and place it, as shown by *c i*, and through *i* draw the line D C; 1 A *a* B 1 is then the pattern for the end piece and A *a* B C D the one half pattern for the middle piece, which, however, can be made any desired length. By tracing 1 1 C D opposite the line C D the full patterns are obtained, to which edges must be allowed for seaming and riveting.

Fig. 214 shows how to obtain the pattern for a cylinder fitting on an inclined roof. A represents the cylinder and B C the pitch of the roof. From D at right angles to the pipe draw D *a*. Then *a b* becomes the rise of the miter line. Now cut a piece of metal equal to the girth of the round pipe A, to which edges have been allowed, as shown by 1 1° D B in Fig. 215, and divide the girth 1 1° into any convenient number of even spaces. Use the metal T-square and erect lines, as shown. Place the rise *b a*, in Fig. 215, as shown, from 1 to 7′ in Fig. 215. Bisect 1 7′ and obtain *d*, which use as a center and describe the semicircle 1 4′ 7′, which divide into half as many spaces as contained in 1 1°, as shown by similar figures. With the metal T-square from the various intersections in A intersect vertical lines previously drawn. Through these intersections draw the miter cut 1 C 1°. Then B 1 C 1° D is the desired pattern. The rule given in Fig. 215 can be applied whether the pipe A in Fig. 214 is square, rectangular or round.

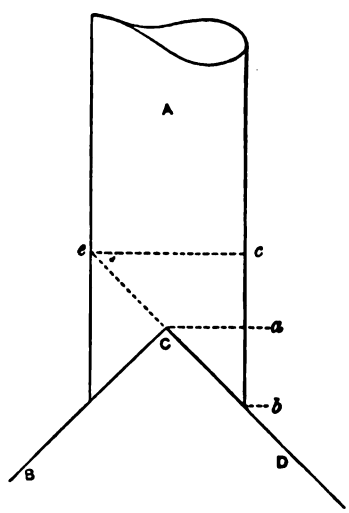

Fig. 216. Cylinder on Double Pitched Roof

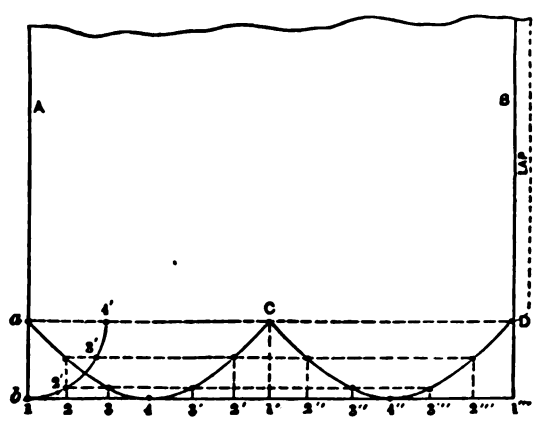

Fig. 217. Pattern for Cylinder on Double Pitched Roof

In Fig. 216 is shown the cylinder A mitering on a double pitched roof, shown by B C D. From C draw the horizontal line C *a*. Then *a b* is the rise of the miter line. Obtain the girth of A in the usual manner and cut a piece of metal of the required size, as shown in Fig. 217. Space the girth into an even number of

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spaces, as shown from 1 to 4, 4 to 1′, 1′ to 4″ and 4″ to 1‴, and with the metal T-square draw lines, as shown. Take the distance from *b* to *a*, in Fig. 216, and place it, as shown, from *b* to *a*, in Fig. 217. With *a* as a center and *a b* as radius draw the quarter circle *a b* 4′ which divide into one fourth as many spaces as there are spaces in 1 1‴. From the various intersections in the quarter circle draw lines parallel to 1 1‴ until they meet similar vertical lines, as shown. A line traced through points thus obtained, as shown by *a* C D, will be the desired pattern. In the previous problem, Fig. 215, a semicircle was used, because the cylinder intersected a roof of one inclination, as shown in Fig. 214. In this problem but one quarter of a circle is used because the cylinder A, in Fig. 216, miters against a double pitched roof. This is easily proved by extending the line D C, in Fig. 216, until it cuts the side of the cylinder at *e*. From *e* draw a line to *c*. Now *c a* and *a b* are equal, and *a* would be the center point with which to draw the semicircle, radius of which is equal to *a b* or *a c*, as was done in Fig. 215. In Fig. 217 a quarter circle is only used, because C *b*, in Fig. 216, is one half of *b e*.

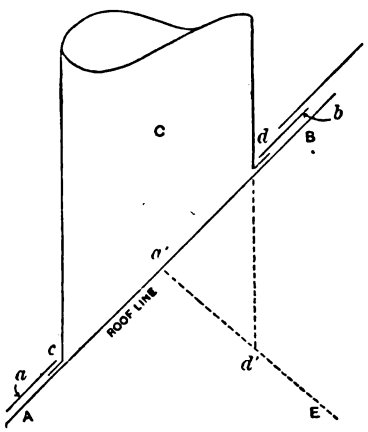

Fig. 218. Sectional View of Roof Flange

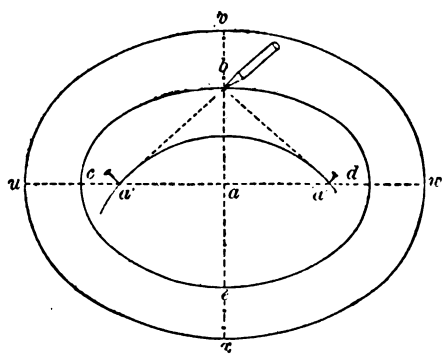

Fig. 219. Pattern for Roof Flange

When a roof flange is required to fit around a cylinder butting against a single or double pitched roof a simple and quick method for obtaining same is shown in Fig. 219. Let A B in Fig. 218 be the pitched roof, against which the cylinder C miters; *a b* represents the roof flange soldered to the cylinder at *c* and *d*. Now knowing the diameter of the cylinder C and the length of the opening *c d*, the flange is developed as follows:

Draw any horizontal line in Fig. 219, as *c d* equal to *c d* in Fig. 219. Bisect *c d* in Fig. 219 and obtain *a*, through which at right angles to *c d* draw *e b*, making *a b* and *a e* each equal to one half the diameter of the pipe C in Fig.

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218. With a radius equal to one half of *c d*, as *a d* or *a c*, and with *e* as center, describe an arc cutting the line *c d* at *a'* and *a''*. Drive a nail at *a'* and another at *a''*. Tie a piece of spool wire around these two nails long enough so that when the wire is drawn taut it will reach point *b*. Now, using a pencil or scribe awl, draw the ellipse, shown by *c b d e*. Knowing the width of the flange *a* or *b* in Fig. 218, set the dividers equal to this distance and scribe a line parallel to *e d b c*, as shown by *u v w x* in Fig. 219. These flanges are usually made in two parts with a seam on *u c* and *d w*, which enables the flange to be placed around the cylinder C in Fig. 218 from both sides.

When the cylinder C in Fig. 218 butts against a double pitched roof, shown by A *a* E, it is only necessary to take the distances *c a'* and *a' d'* and place them as shown by *c a* and *a d* in Fig. 219 and proceed as before. In this case a bend would be made along *v x* in the pattern to correspond to the angle A *a'* E in Fig. 218. By a little study and foresight time can be saved by using the foregoing rules when developing sheet metal work of this kind.

PATTERNS FOR A PIPE TO DESCRIBE A HELICAL CURVE ABOUT A CYLINDER

A pipe 6 inches in diameter is required to wind around a cylinder 24 inches in diameter so that the rise at each revolution shall be 30 inches, as shown in Fig. 220, the number of pieces in each revolution being 16. It can be readily seen that the pattern will not be the same as that of an ordinary elbow and it will be something like what is shown at A, the throats of the two miters being marked by the arrow points. What is desired particularly is how much the throat of the miter at one end of a piece is placed to one side of that at the other in order to produce the required twist.

Perhaps it would be more accurate, however, to say that each miter in itself is the same as would be required for an elbow of the same curve, but that the wind is produced by theoretically turning one end of each piece of the elbow axially upon the other end, thereby throwing the throats of the two miters out of line. This is accomplished in the pattern by shifting the position of the stretchout for one end of the pattern a sufficient amount above or below that of the other, as indicated. The problem consists, then, in determining just how much to turn the throat of one miter around from that of the other, or, in other words, in finding the exact angle between the lines of the two throats, as seen in an end view of a section of the pipe.

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In the case of a helix consisting of a great number of pieces to each revolution, say 16 or more, the amount of turn in each piece is so slight that the desired result might be practically obtained by judicious manipulation in the process of putting the pieces together. The twist is further decreased of course as the pitch, or rise, of the spiral decreases. The conditions given in the sketch, Fig. 220, are such, however, as to make the difference in the positions of the throats quite appreciable. There are several ways in which this difference may be derived from accurately made drawings. Probably the simplest way is that of developing a correct elevation of the helical curve. This may be properly accomplished by first drawing a plan, as shown in the lower part of Fig. 221, above which the elevation is projected in the usual way.

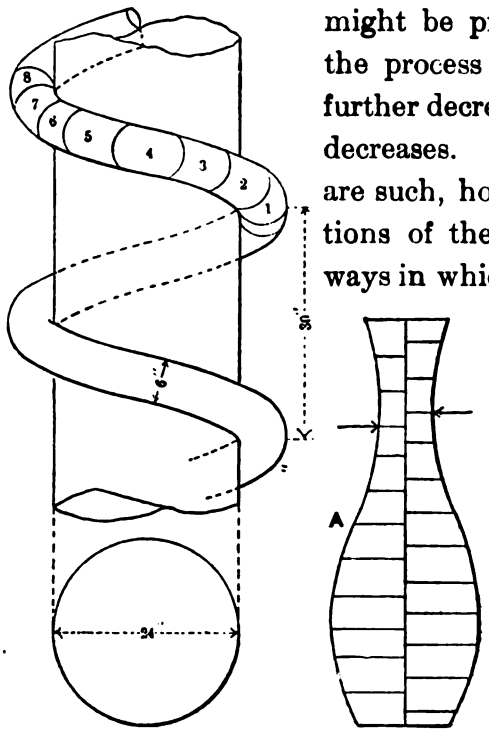

Fig. 220. A Sketch of the Problem

In this figure A B C shows a half plan of the vertical cylinder, around which the winding pipe, made up of the required number of pieces, is drawn, as though laid in a horizontal plane. In drawing the several pieces of the pipe on the plan, it is best to divide the circumference of the 24-inch cylinder so that the middle of one of the pieces (not a miter) shall fall on the center line of the plan and elevation. As all the pieces required to form the spiral must necessarily be alike, this arrangement will give a normal elevation of the central piece, from which its correct length may be measured and its miter lines obtained. Therefore, divide the semicircumference A B C of the plan into 16 equal spaces and through the alternate points *a*, *b*, *c*, etc., draw lines from the center D, extending them to represent the miters of the small pipe. From B set off on the center line B D extended, the diameter and semidiameter of the small pipe, as shown at E and F. Through B, F and E draw lines parallel to A C, representing the sides and axis of the pipe, continuing them till they intersect the miter lines *d* G and *e* H. Now, from D as center with D G as radius draw a semicircle, shown dotted, cutting the several miter lines as shown. Connect the several intersections, as G J, J K, etc., thus obtaining the outer line of the spiral pipe, and continue the inner axial lines parallel with the outer line from the points of intersections with *d* G, all as shown. From each of the points of intersection of the axial line with the several miter lines of the plan, as 1, 2, 3, etc., project lines upward through the elevation indefinitely.

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It will now be necessary to divide a space of 30 inches in the vertical hight of the cylinder into as many spaces (16) as there are pieces in one complete revolution of the helical pipe. The same result will be obtained if desirable, by dividing 15 inches of the hight into eight spaces and using half the plan. Therefore, at any

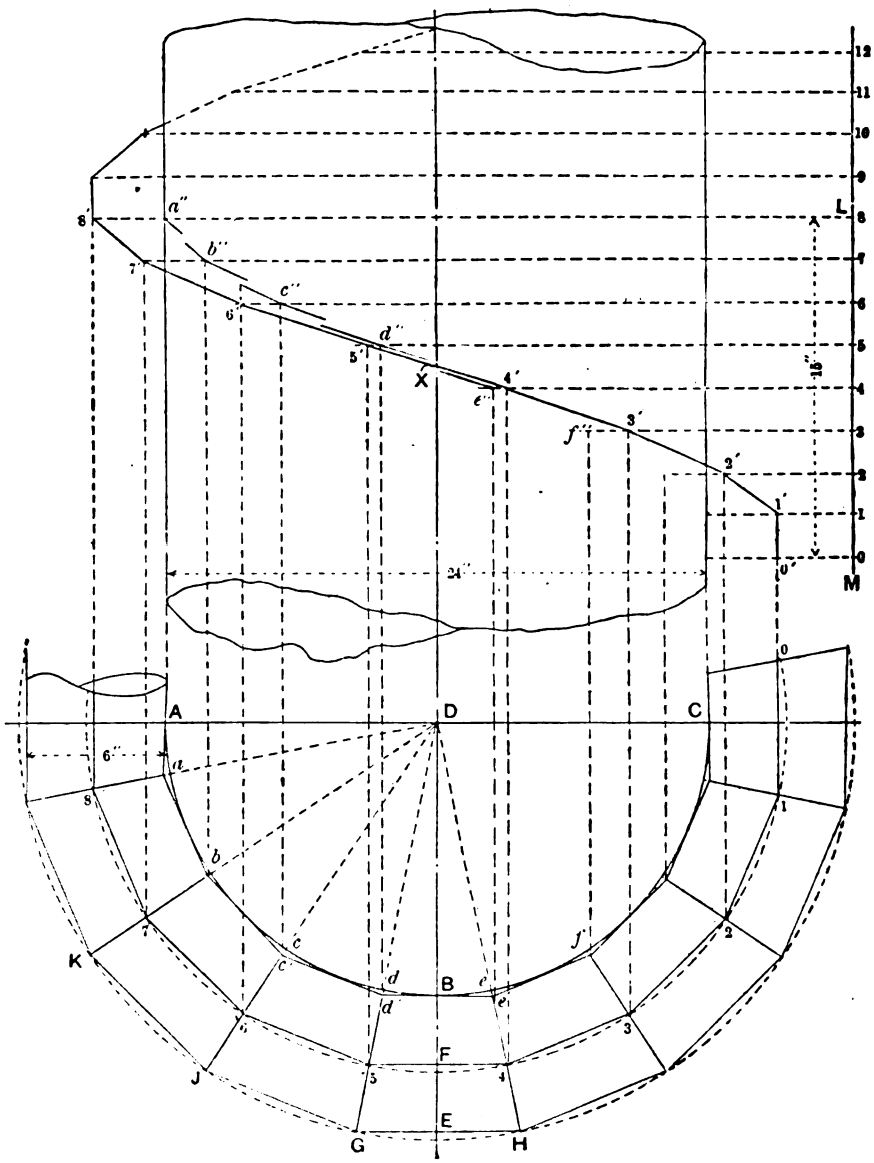

Fig. 221. Plan and Elevation of the Cylinder and Winding Pipe, Showing Method of Developing the Lines of the Spiral Curve

convenient point outside the elevation of the cylinder draw any line, as L M, 15 inches long, and divide the same into eight equal spaces. From each of the points of division in L M draw horizontal lines across the elevation, intersecting each with the line of corresponding number just drawn from the plan. It should be noted

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that the numbers of the points in the plan and in the line L M should increase in the same direction, as, for instance, in the direction of the rise of the pipe. Straight lines connecting the adjacent points of intersection in the elevation, as shown by 0′ 1′, 1′ 2′, 2′ 3′, etc., will then represent a correct elevation of the axis of the spiral pipe throughout one half a revolution, and the line 4′ 5′ will show the correct length and inclination of the axis, or center line, of the middle piece, shown by 4 5 of the plan. Upon this line 4′ 5′ may be constructed the complete elevation of one piece if desired, but as it is not really necessary in obtaining the final result it has been omitted.

An inspection of the plan will now show that while the lines 3 4, 4 5, etc., of that view are inclined at the angle shown by 4′ 5′ of the elevation, the lines *e* H, *d* G, *c* J, etc., are drawn horizontally through the intersections, or meeting points, 4, 5, 6, etc., of the axes of the several pieces, and that these lines when extended to D intersect the vertical axis of the large cylinder, not at one point, as the plan might seem to indicate, but at various hights, shown respectively by the figures in L M. If, therefore, vertical lines be erected from the points *e′*, *d′*, *c′*, etc., representing the throats of the miters in the plan, to intersect with the horizontal lines of corresponding number of the elevation—that is, from *e′* of the plan to intersect with the line from 4 in L M, and from *d′* with 5 in L M, etc.—the several points so obtained will show the true positions of the throats of the several miters in the elevation, as indicated by *c″*, *d″*, *c″*, etc. If now lines be drawn from *e″* and *d″* parallel to 4′ 5′ toward the center line, the distance between these lines shown at X will give the exact amount that the stretchout for one end of the pattern must be shifted above or below that of the other end to produce the desired pattern for one piece of the spiral elbow.

Inasmuch as the distances 4 5, 5 6, etc., of the plan in Fig. 221 do not represent the true lengths of the axes of the pieces on account of the inclination of those lines, as before mentioned, it will be necessary before attempting to develop the pattern that a correct plan of one piece be drawn. Therefore, draw the line D E of Fig. 222 equal in length to D E of Fig. 221, and on this locate the points B and F correspondingly. Through the point F draw the center line 4′ 5′ at right angles to D E, making it equal in length to 4′ 5′ of the elevation, Fig. 221, and from D draw lines through points 4′ and 5′ indefinitely, constituting the true miter lines. Upon 4′ 5′, extended to any convenient point, and with C as center and with B F as radius, describe the profile as shown. Beginning now at the point 0, corresponding to the throat B of the miter, divide the profile into any suitable number of equal spaces and set off a stretchout of the same on D E, extended as shown

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toward S. Measuring lines for the miter at one end of the piece may now be drawn to one side, as to the left, for the pattern of that end of the piece, after which the stretchout must be repeated on the same line E S, beginning at a point, *n*, the distance of which below 0 of the other stretchout, is equal to the distance X obtained in the elevation, Fig. 221. From the points of the second stretchout the measuring lines are now drawn to the right and the remaining operations necessary to complete the pattern conducted in the usual manner. Of course, that portion of the right half of the pattern which projects beyond the other side, shown at *m*, must be transferred to the top so as to make a straight joint at the throat, where the usual lap will be allowed. In putting the miters together great care must be taken to bring the point *h* at the left end of one piece to the point *k* at the right end of the adjacent piece.

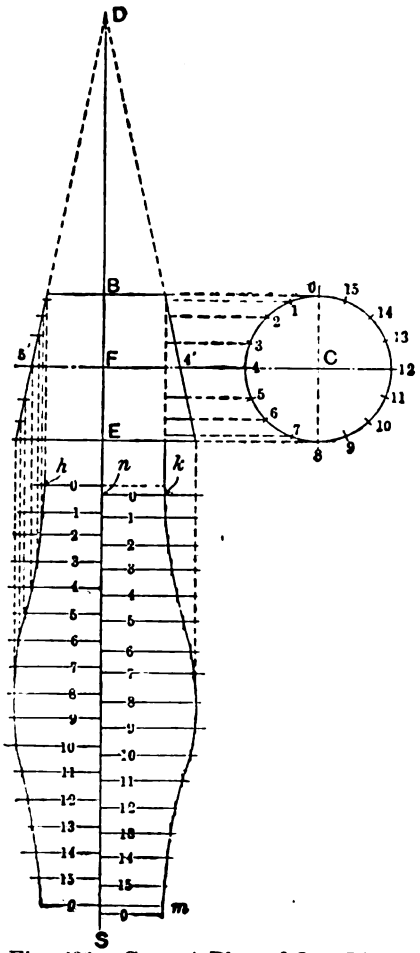

Fig. 222. Correct Plan of One Piece, Showing Manner of Laying off Stretchout

Much of the work described in connection with Fig. 221 and shown therein is done for explanatory reasons and can be omitted in actual practice. After the plan A B C and the line L M have been divided into the requisite number of spaces, the parts of the drawing really necessary to obtain the final result are those portions between the lines *d* G and *e* H of the plan and between 4′ and 5′ of the elevation. It must also be noted in forming the pieces that that portion of the pattern from 0 to 8 of the stretchout forms the under side of the piece, for if formed so as to bring it on the upper side, the joining of the miters as above described would produce a spiral inclining downward toward the left instead of upward, as in Fig. 221.

PATTERN FOR TWISTED TRANSITION ELBOW

The drawing shown by Fig. 223 is for some piping in a grain elevator. The connections of this must be made in the elbows and the flare on the side of the top elbow must be made all on one side, so as to pass the rafters in the building.

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By referring to the front elevation, it will be seen that three different fittings are used. A shows a pieced elbow, shown in side view by A^1, B is a transition piece joining the round elbow at *a*, shown in side view by B^1, while C is a twisted transition elbow, 20 inches square at *b*, flaring to one side, as shown, to connect with a pipe 9×35 inches, and is shown in side view by C^1. The pieced elbow at A is cut in the usual manner, while the transition B is developed as shown in "The New Metal Worker PatternBook" on page 336.

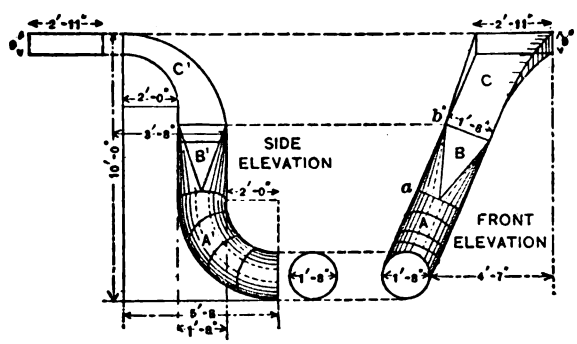

Fig. 223. Dimensions and Views of the Problem

In laying out the elbow C, to avoid a confusion of lines, which would occur in so small a space, enlarged diagrams are shown in Fig. 224, in which 1 2 12 11 is the side of the elbow shown in front by 1, 2, 2°, 1°, 12° and 10, which represent similar shapes, as shown by C^1 and C respectively in Fig. 223. The first step in Fig. 224 is to divide the two curves in side view into an equal number of spaces, as shown by the small figures 2 to 12 on the outer curve and 1 to 11 on the inner curve. At right angles to 1 2 in side elevation and from points 2 to 12 on the top curve, draw horizontal lines intersecting the top of the elbow in front elevation at 2, 4, 6, 8 and 10 on the line 2 10, and at 2°, 4°, 6°, 8°, 10° and 12° on the line 2° 12°, as shown. In similar manner, at right angles to 1 2 in side elevation and from points 1 to 11 on the bottom of the elbow, draw horizontal lines intersecting the bottom of the elbow in front elevation at 1, 3, 5, 7 and 9 on the line 1 9, and at 1° 3° 5° 7° 9° and 11° on the line 1° 11°, as shown. In this connection it should be understood that the corner or miter lines 2 10, 1 9 and 2° 12°, 1° 11° are drawn at pleasure after the dimensions are obtained; but when once drawn remain fixed lines.

For the pattern for the top of the elbow proceed as follows: At right angles to 2 2° in front draw the line 12′ 2′, upon which place the stretchout of the top curve 2 to 12 in side elevation, as shown by 2′ to 12′ on the line 12′ 2′. At right angles to 2′ 12′ and from the small figures draw lines, as shown, which intersect with lines, not here shown, drawn from points having similar numbers on the miter lines 2 10 and 2° 12° at right angles to 2 2° in front elevation, thus obtaining similarly numbered intersections in A. A line traced through the points thus obtained, as shown by 2 2° 12° 10, will be the pattern for the top of the elbow.

For the pattern for the bottom draw a line, 1′ 11′, at right angles to 10 9°, upon which place the stretchout of the bottom curve 1 11 in side elevation, as shown by

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similar numbers on 1′ 11′. At right angles to 1′ 11′ and from the small figures draw lines, as shown, which intersect with lines, not here shown, drawn from points having similar numbers on the miter lines 1 9 and 1° 11° in front elevation

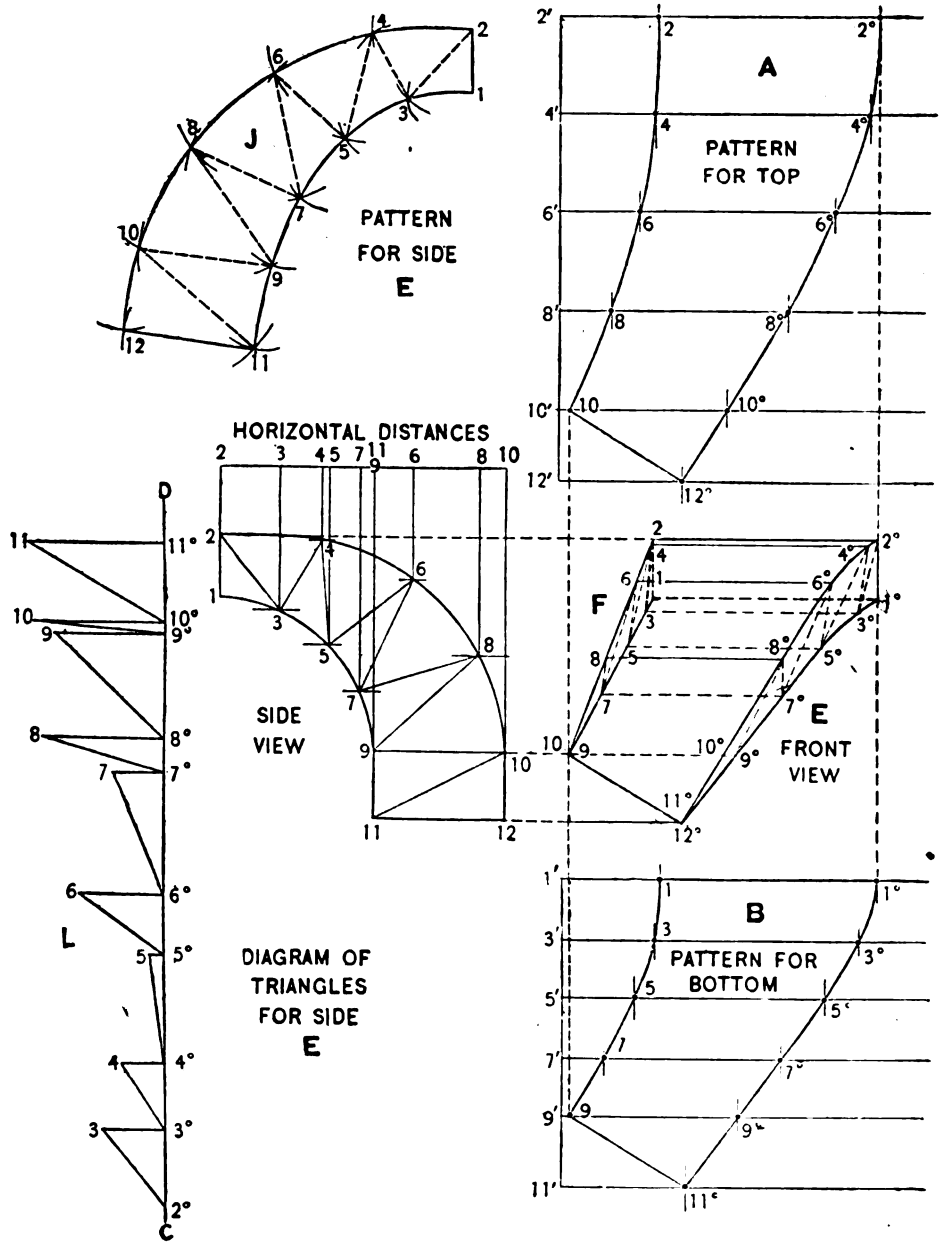

Fig. 224. Side and Front Views, Diagrams of Triangles and Patterns

at right angles to 9 9°, thus obtaining similar numbered intersections in B. A line traced through points thus obtained, as shown by 1 1° 11° 9, will be the pattern for the bottom of the elbow.

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The patterns for the sides E and F will be developed by triangulation. As the method used for obtaining the pattern E can also be applied to F, only the side E will be developed. Now, from the various points in the side view connect lines 2 to 3 to 4 to 5 to 6, 7, 8, 9, 10 and 11, as shown. In similar manner, in the side E in front connect points 2° to 3° to 4° to 5° to 6°, 7°, 8°, 9°, 10° and 11°, as shown, and proceed in the same manner for the side F by connecting 2 to 3 to 4 to 5 to 6, 7, 8 and 9, all as shown. Then will the lines shown in E and F represent the bases of the triangle which will be constructed, and the horizontal distances between the points in the side view the altitudes or hights. To obtain these horizontal distances in the side view draw any horizontal line, 2 10, on which erect perpendicular lines drawn from the various points in the side view, as shown, thus obtaining similarly numbered figures on 2 10 corresponding to those in the side view.

For the diagram of triangles for E erect any line, as C D, as shown. Now take the various distances in the dividers in the side E, as from 2° to 3°, 3° to 4°, 4° to 5°, 5° to 6°, 6° to 7°, 7° to 8°, 8° to 9°, 9° to 10° and 10° to 11°, and place them on the line C D, as shown by distances having similar numbers. At right angles to C D draw lines from the various points, as shown. Then take the various horizontal distances and place them on similar lines just drawn. For example, take the horizontal distance 2 3 and place it, as shown, from 3° to 3 in the diagram of triangles, and draw a line from 3 to 2°. In similar manner take the horizontal distance from 3 to 4 and place it, as shown, from 4° to 4 in the diagram of triangles and draw a line from 4 to 3°. In this manner obtain all of the triangles for the twisted side E. Then, using these triangles and the patterns for the top and bottom, the miter lines of which show the developed lines for the corners of the elbow, all is ready to strike out the pattern for the twisted side E in front. Thus, in J draw any line, as 1 2, equal to 1° 2° in E. Now, with 1° 3° in B as radius and 1 in E as center describe the arc 3, which intersect by an arc struck from 2 as center with 2° 3 in L as radius. With 2 in J as center and 2° 4° in A as radius describe the arc 4 in J, which intersect by an arc struck from 3 as center and 3° 4 in L as radius. Proceed in similar manner for the balance of the pattern, using alternately, first the divisions on the miter cut 1° 11° in B, then the proper numbered slant line in L, the divisions on the miter cut 2° 12° in A, then the proper numbered slant line in L, until the last line, 11 12 in J (which is obtained from 11 12 in the side view), is obtained. A line traced through points thus obtained, as shown by 1 2 12 11 in J, will be the pattern for the side E. In precisely the same manner obtain the pattern for side F.

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PATTERN FOR COMPOUND CURVED TAPERING ELBOW

The following exemplifies the correct method of laying out the patterns for a reducing elbow having a compound curve, as shown in Fig. 225. The elbow curves 90 degrees in plan and reduces from 15 to 10 inches. The center of the 10-inch pipe is placed 18 inches below the 15-inch opening in the blower.

First draw a correct plan and elevation of the elbow when viewed in the direction of the arrow in Fig. 225. This has been done in Fig. 226. With a radius of 2 feet 5 inches and A as center, draw the quarter circle B C. As the elbow is to be six pieced, divide B C into five spaces, placing two halves, as shown, from B to *a* and C to *e*. Through *a*, *b*, *c*, *d* and *e* draw radial lines, as shown. From B and C draw vertical and horizontal lines, respectively, intersecting the lines A I and A E at *m* and *f*. Take the distance of A *m* and place it on the balance of the radial lines, as shown by *h*, *i* and *j*. Draw lines *m j*, *j i*, *i h* and *h f*. Make the distances B J and B J° each equal to 5 inches and draw vertical lines from J and J°, intersecting the miter line at I and I°. In a similar manner make the distances C D and C D° each equal to 7½ inches and draw horizontal lines, intersecting the miter line at E and E°. These two end sections of the elbow are parallel pieces of pipe, the patterns for which are obtained as in ordinary elbow work, the half sections of the 10 and 15-inch pipes being shown, respectively, by *m* in elevation and C in plan.

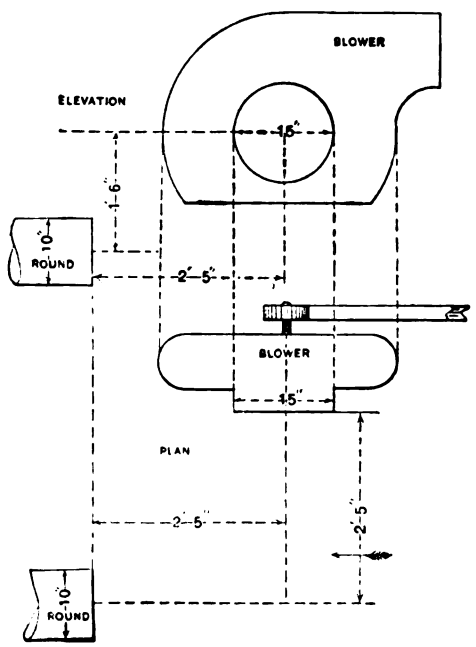

Fig. 225. A Sketch of the Problem

It is now necessary to obtain a proportional taper between I and E in plan. This is done by taking the distances of *m j*, *j i*, *i h* and *h f* and placing them on any vertical line, as *m' f'*, as shown by similar letters. From *m'* and *f'* draw horizontal lines, making *m'* I^1 and *f'* E^1 equal, respectively, to *m* I and *f* E in plan. Draw I^1 E^1, and from *j''*, *i''* and *h'* draw horizontal lines, intersecting I^1 E^1 at H^1, G^1 and F^1. Take the various distances, *j''* H^1, *i''* G^1 and *h'* F^1, and place them on the miter lines in plan, as shown by *j* H and *j* H°, *i* G and *i* G°, *h* F and *h* F°. Draw I H G F E and I° H° G° F° E°. Then will J D D° J° represent the plan of the elbow.

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As the vertical distance from the center of the 10-inch pipe to the center of the 15-inch pipe is 18 inches, and as the elbow has four tapering sections in plan, then, on the line erected from A in plan, make m'' f'' equal to 18 inches. Divide the same into four equal spaces, as shown by h'', i'' and j''. From these divisions, draw horizontal lines which intersect by lines erected from similar letters in plan, representing the center points on the miter lines and resulting in the points of intersections f, h, i, j and m in elevation. The heavy dotted line traced through these points represents the center line of the elbow around which the tapering elbow must be constructed.

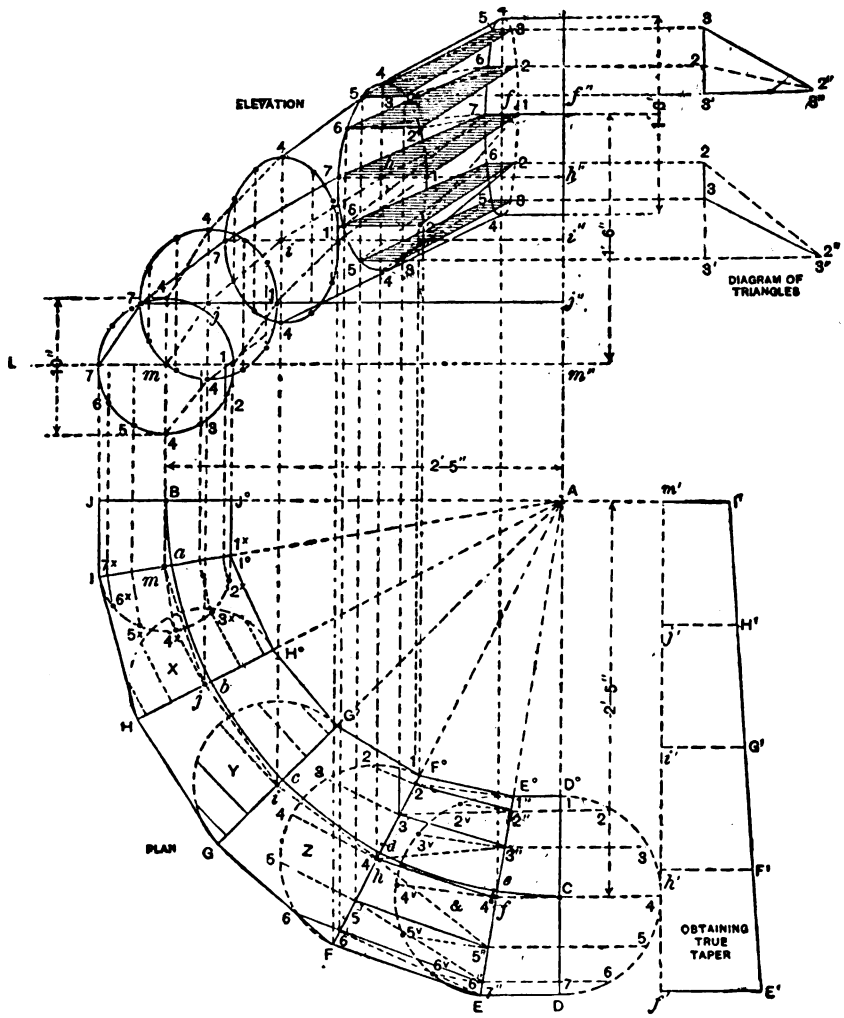

Fig. 226. Obtaining Miter Lines

To obtain this construction the elevation of the miter lines in plan must be projected as shown, after which each section (excepting the top and bottom) is developed by triangulation. With m in elevation as center, draw the 10-inch circle shown, and divide the lower half into equal spaces, shown from 1 to 7. From these points drop lines intersecting the miter line I I° in plan. At right angles to I I°, and from the intersections on same, draw lines as shown by 2^x 6^x, which are equal to similar lines 2 6 in the half circle m in elevation. 1^x 4^x 7^x is then the true section on I I° in plan. In similar manner, place the half section of the 15-inch pipe on D D° in plan and divide same into the same

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number of spaces, as *m* in elevation, and obtain the true section on E E° in plan, as shown by 1″ 4″ 7″. At pleasure construct true sections on the miter lines H H°, G G° and F F°, which in this case have been assumed to be circles divided into the same number of spaces as in *m*. From the various intersections in X, Y and Z draw perpendiculars, cutting the miter lines as shown.

The method of obtaining the miter line in elevation on F F° in plan will explain the principles required for obtaining the other miter lines in elevation. From the intersections in Z lines are drawn perpendicular to F F°, intersecting same from 2′ to 6′. From these intersections vertical lines are projected into the elevation indefinitely, as shown. Through *h* in elevation, draw the horizontal line intersecting the vertical lines drawn from 1 and 7 in plan at 1 and 7 in elevation. Now, measuring from the line F F° in plan, take the various distances to points 2 to 6 and place them in elevation on similar lines measuring above and below the line 7 1 in *h*. A line traced through the points thus obtained, as shown by 1 4 7 4 1 in *h*, will be the miter line on F F° in plan.

Having obtained the miter lines, each section must be developed by triangulation. This is done by connecting similar points by solid lines and opposite points by dotted lines, as is shown in both plan and elevation for the upper section, *h f*; and requires no further explanation, as many examples are here presented.

PATTERN FOR A ROOM AIR DIFFUSER

In connection with the ventilating systems provided in New York schools, a diffuser of sheet metal is used at the air opening into the room wall to spread and direct the air, so far as possible, to get satisfactory circulation within the room and without giving rise to air drafts. The diffuser serves to direct the air upward more or less against the ceiling to spread the air in strata, which will descend more or less generally over the entire room area rather than in distinct currents. As the flues of a school building naturally come at different distances from the outside wall, the diffusers vary slightly in design to take account of this fact. The closer the air opening is to a corner of a room, the more is it desired that the air shall be directed away from the corner and to the center of the room, while a diffuser situated at the center of a wall would probably be designed to spread the air equally on both sides of the diffuser. As the pattern cutting of these diffusers is of more than passing interest, the following demonstration of the way that they are cut out has been obtained from a reader, who has had considerable of this work to do.

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The accompanying drawings, Fig. 227, show the side elevation and the front elevation of one of the diffusers, in which it will be noted that it is calculated to divert more air toward the left than toward the right. The procedure in working up the pattern is as follows: The profile A B in the side elevation is divided into a convenient number of equal parts, in this case 10. From these points lines are extended horizontally until they intersect the miter line C D of the front elevation. Above the front elevation, in the usual way, is laid off the line X Y perpendicular to the horizontal lines, and on this is indicated the stretchout of the profile A B. Vertical lines from the points of intersection on the miter line C D

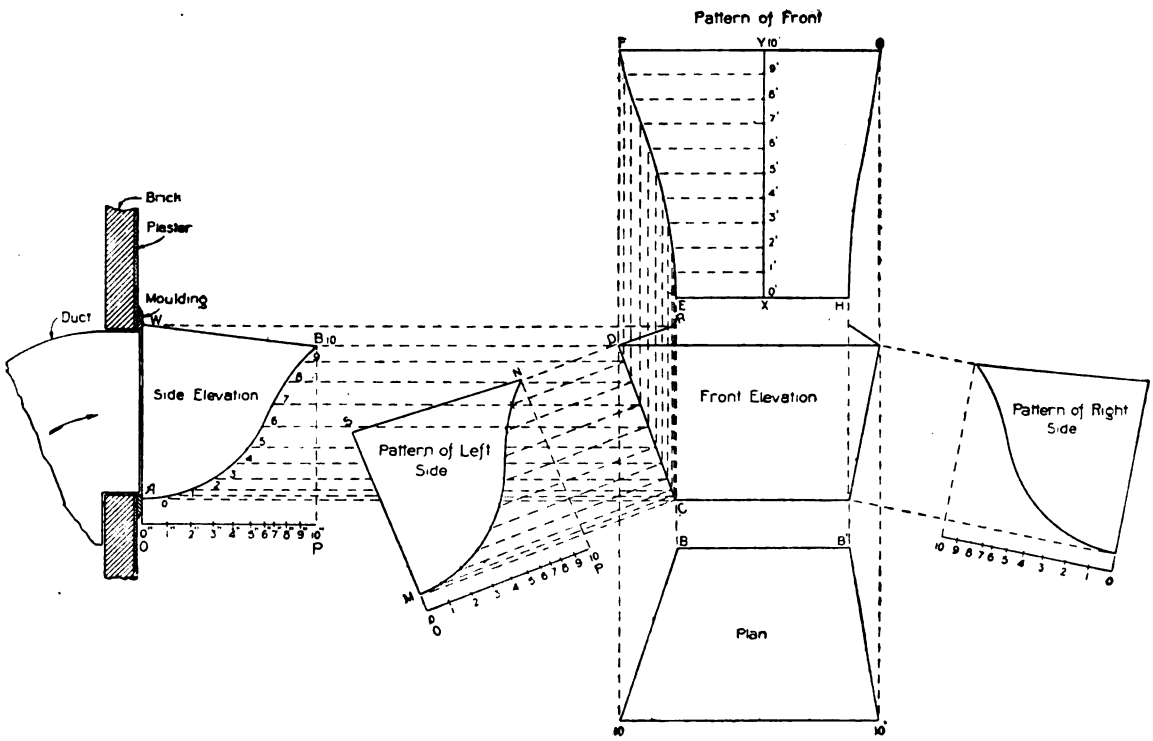

Fig. 227. Air Diffuser of Sheet Metal for Fresh-Air Inlet Openings of New York School Rooms

and horizontal lines drawn through the points 0′, 1′, 2′, etc., of the stretchout, intersect in a series of points, giving the curve of one side of the pattern of the front. This curve is E F. The outline H G is obtained in the same way, so that E F G H is the pattern of the front.

The pattern of each side is obtained in an equally simple manner. A horizontal line O P is drawn underneath the side elevation. Lines are projected from the points of division on the profile, obtaining the points 0″, 1″, 2″, 3″, etc. Perpendicular to the miter line C D in the elevation, lines are drawn from the points of intersection on the miter line, these lines being projected indefinitely to the

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left of C D as indicated. Parallel with these lines and at some convenient point is laid off the line O P with the exact location of the points 0″, 1″, 2″, 3″, etc. Lines projected perpendicular to the new location of O P intersect corresponding lines perpendicular to C D, and a curve drawn through points of intersection gives the true curve of the miter line of the left side of the pattern.

The point S is not obtained as might first be assumed from the drawing by continuing line D N until it is intersected by the line O S. Instead, the true length of W B of the side elevation is obtained. An arc is then described about N as a center, with a radius equal to this true distance, and where this arc is intersected by another arc described about the point M as a center and with a radius equal to the distance C R of the front elevation, is determined the position of S.

In order to get the true length of the line W B, a plan is drawn below the front elevation, with the two parallel lines B B′ and 10 10′ spaced apart equal to the distance W B of the side elevation. Lines projecting vertically downward from C and D locate the points B and 10 and then B 10 is the true length of W B. The arc described about the center N therefore has a radius equal to B 10. The true length of the other radius is that given directly by C R. The intersection of the two arcs determines the location of S, and S M N is therefore the pattern for the left side. The pattern for the right side is obtained in a similar way.

PATTERNS FOR A BRANCH—INTERSECTING SCALENE CONE AND TRANSITION PIECE

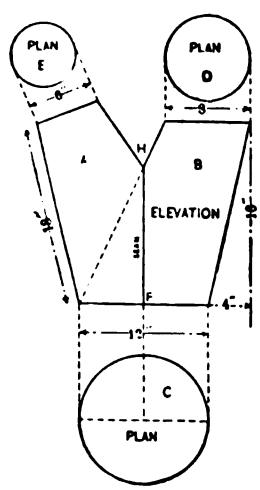

Fig. 228 Sketch of the Problem

This article deals with the method of cutting the patterns for the branch reproduced in Fig. 228, which portrays the conditions imposed—conditions that are of frequent occurrence in the trade. As will be seen, the problem involves a transition piece, A, intersecting the scalene cone B. The seam is to come on a vertical line central over the center in plan; and it is to be understood that cylindrical collars would be attached at the 6-in., 8-in. and 12-in. openings, but as they involve no especial principles of pattern cutting, they were not detailed in this figure.

Fig. 229 is an enlarged view. Extend G F and A E until they intersect at X. From X, and from A, Y and H, the center points of B C, E F and A G, drop lines inter-

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secting Z &. Divide the base in plan, I J K L, into equal spaces, as shown by 1 to 7, and from these points draw radial lines to the apex &, as shown. The line of joint is shown by D H in elevation, and as the point H comes over the point 4 in plan, to obtain a plan of the joint line erect at right angles to I & and from points 1, 2 and 3, lines intersecting A G at A, *b* and *c*. From these points draw lines to the apex X, cutting H D at 1′, 2′, 3′. As the joint, or rather seam, D H is a perpendicular line in elevation it will consequently show a straight line in plan, L J, and will intersect radial lines in plan at 1″, 2″, 3″ and 4″.

Trace the ellipse D^1 E^1 C^1 Z, which is the plan of B C in elevation. Draw D^1 L and C^1 J. Then will D^1 L J C^1 Z be the plan of the irregular transition piece, shown in elevation by A B C D H. L J P K^1 O represents the plan of the scalene cone, shown in elevation by H G F E D.

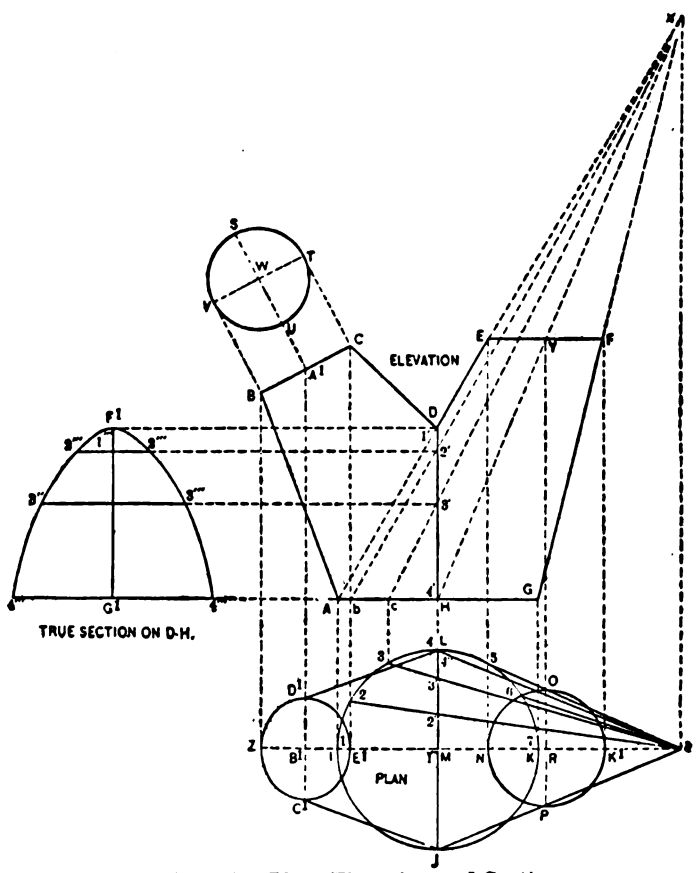

Fig. 229. Plan, Elevation and Section

From the intersections 1′, 2′, 3′, 4′ on D H of the elevation draw lines parallel to G A, extending them to the left, as shown, intersecting the vertical line F^1 G^1, onto which the true section on D H is to be constructed, as follows: Measuring in every instance from the center line Z & in plan, take the distances in the dividers to points 2″, 3″ and 4″ and place them on the horizontal lines having similar numbers, measuring right and left from F^1 G^1, as shown by intersections 1‴, 2‴, 3‴ and 4‴ on either side. Trace a line through the points thus obtained and 4‴ 1‴ 4‴will be the section D H.

For the pattern for the scalene cone proceed as follows: Let X E A G F of Fig. 230 be a reproduction of similar letters and figures in elevation in Fig. 229, and let the half plan I J K be a reproduction of similar half plan in Fig. 229, with the divisions similar to those on I L K. Then with & in Fig. 230 in plan as

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center and radii equal to & 1, & 2, & 3, & 4, etc., draw arcs intersecting the line I K, as shown. At right angles to I K and from the intersections on same draw lines intersecting A G, as shown by 1′ to 7′. From the intersections on A G draw lines to the apex X, intersecting the top of the cone E F, as shown by points 1 to 7.

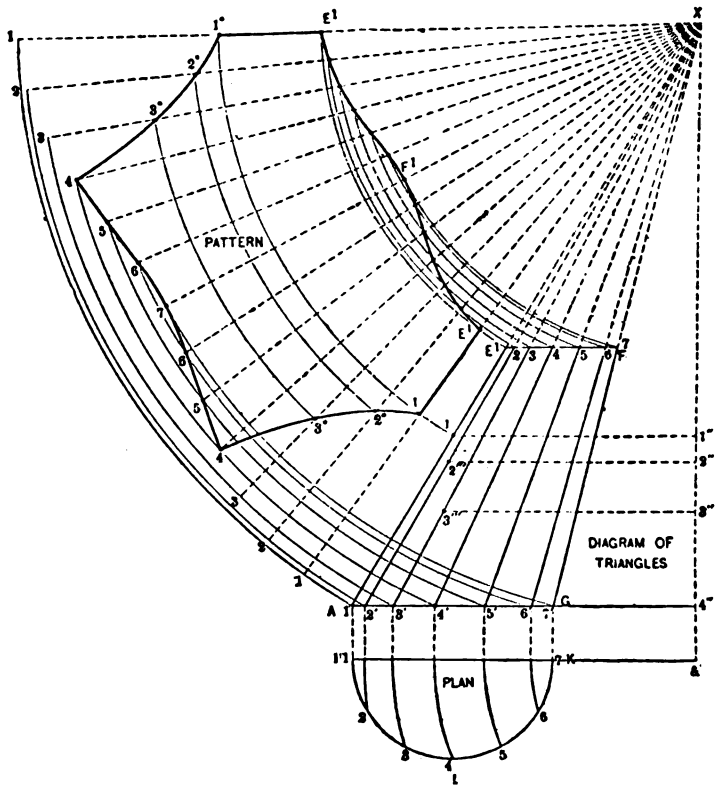

Fig. 230. Plan and Elevation, and Pattern for Scalene Cone

Extend A G to 4″. Now take the various hights in elevation in Fig. 229, as 4′, 3′, 2′ and 1′ on D H, and place them on & X in Fig. 230, starting at 4″, obtaining the points 3″, 2″ and 1″. At right angles to X & and from 1″, 2″, 3″ and 4″ draw lines intersecting hypotenuses of triangles having similar numbers at 1‴, 2‴, 3‴ and 4′. Now, with X as center and radii equal to X 1′, X 2′, X 3′, etc., draw arcs indefinitely, as shown. Set the dividers equal to the spaces into which the plan is divided, and, setting one leg of the dividers upon the arc 1, step from one arc to the other, placing the division 2 of the plan on the arc 2 in the pattern, 3 of the plan on the arc 3 in the pattern, until all of the divisions necessary to complete the full pattern are obtained, as shown by the small figures 1 to 7 and 7 to 1. From these figures draw lines to the apex X. Now, with X as center and radii equal to X 1‴, X 2‴ and X 3‴ draw arcs intersecting radial lines in pattern of similar numbers, as shown by 1°, 2° and 3° on either side in the pattern. Finally, with X as center and radii equal to X 1, X 2, X 3, etc., on E F draw arcs intersecting radial lines of similar numbers in the pattern, as shown. Trace a line through points of intersections thus obtained and E¹ F¹ E¹ 1° 4 4 1 will be the required pattern for the scalene cone.

The patterns for A B C D H in Fig. 229 will be developed by triangulation; therefore in Fig. 231 let 1 14 8 7 22 be a reproduction of A B C D H in Fig.

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229. Take a tracing of the half section V S T and place it as shown by 14 11 8 in Fig. 231. In similar manner take a tracing of the quarter circle I M J in plan in Fig. 229, with the divisions equal to 1 L thereon, and place it as shown by 1 22 4 in Fig. 231. Finally take a tracing of the half section F^1 G^1 4‴ in Fig. 229, with the points of intersections on same, and place it as shown in Fig. 231 by 7 22 4′.

At right angles to 1 22 and from 2 and 3 draw lines intersecting the line 1 22 at 24 and 23. In the same manner, at right angles to 7 22 and from points 5 and 6 draw lines intersecting the line 7 22 at points 21 and 20. As the two

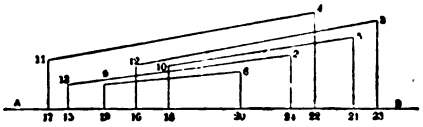

Fig. 232. Diagram of Sections on Solid Lines in Fig. 231

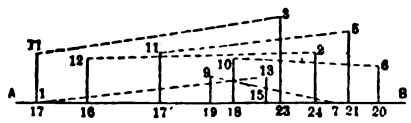

Fig. 233. Diagram of Sections on Dotted Lines in Fig. 231

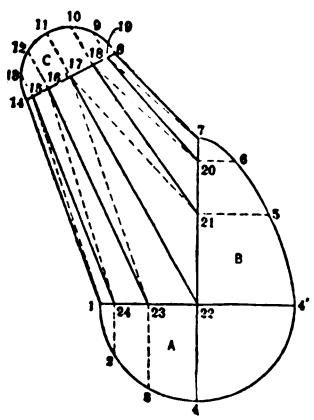

Fig. 231. Diagram for Obtaining Measurements for Sections

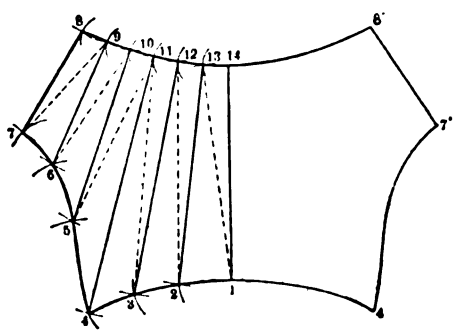

Fig. 234. Pattern Shape for Transition Piece

sections A and B have a total of six divisions, then divide the profile or section C into six spaces, as shown by the small figures 8 to 14. At right angles to 8 14 and from the figures draw lines intersecting 8 14 at points 15 19. Draw solid and dotted lines in 14 8 7 1, as shown. Then will these lines represent the bases, the section of which will be constructed, having altitudes equal to the lines drawn in profiles A, B and C.

For the sections on solid lines draw any horizontal line, as A B in Fig. 232, upon which place the various lengths of the solid lines in Fig. 231, as shown by having similar figures in Fig. 232. For example, take the distance 17 22 in Fig. 231 and place it as shown by the line 17 22 on A B in Fig. 232. At right angles to 17 22 and from points 17 and 22 erect lines, making 17 11 and 22 4 equal to 17 11 and 22 4 respectively in Fig. 231. Draw a line from 4 to 11 in

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Fig. 232, which will represent the actual distance on the finished article on the line 17 22 in Fig. 231.

Proceed in similar manner for all sections on solid lines in Fig. 321, similar parts corresponding to similar figures in Fig. 232. Also proceed in similar manner for diagrams of sections on dotted lines, as shown in Fig. 233 upon the line A B.

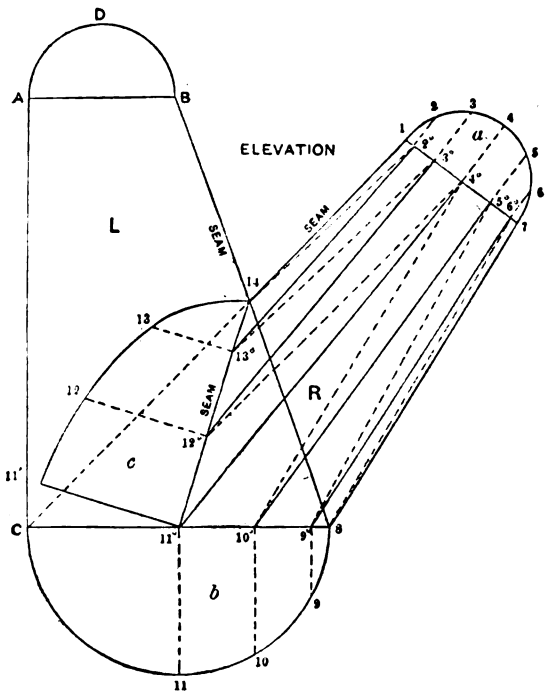

Fig. 235. Elevation and Sections of Branch with Same Diameter

For the pattern draw any vertical line, as 1 13 in Fig. 234, equal to 1 14 of Fig. 231. Now with 14 of Fig. 234 as center and 14 13 of Fig. 231 as radius describe the arc at 13. Then, with radius equal to 1 13 of Fig. 233 and 1 of Fig. 234 as center describe an arc intersecting the previous arc at 13. Next, with 1 2 of Fig. 231 as radius and 1 of Fig. 234 as center describe the arc 2. Then, with 13 2 of Fig. 232 as radius and 13 of Fig. 234 as center describe an arc intersecting the previous arc at the point 2. Proceed in similar manner until all the divisions necessary to complete the pattern have been placed, as shown by similar figures in Fig. 234.

Trace a line through the points obtained, as shown by 14 8 7 4 1, which completes one half the pattern. The other half can be traced opposite.

Should both pipes of the branch be of the same diameter the elevation would be drawn as shown in Fig. 235. After obtaining the true section on the seam line by the aforesaid process the developing of the patterns would be as described for Figs. 229 and 234

ANOTHER METHOD FOR A PATTERN FOR THREE-WAY BRANCH

One of the problems submitted outlined a method of obtaining the pattern for a three-way branch, like that shown on page 88, affording a simple solution for same. It is conditional on having the branches at 45 degrees with each other, but as this is usual in work of the kind the solution is altogether practical.

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As will be seen in Fig. 236, the branches lie all in the same plane, and are all of the same cross-sectional area. The feature of the solution is that only one layout is required and one pattern suffices. Geometrically, the three-way branch, as here outlined, comprises the intersection of parts of three right cones. The cones being identical, the view of the miter line between joining cones is a straight line, as shown in the cut.

The method of obtaining the pattern is pretty clearly indicated. Dotted lines are drawn as usual between ends of the elements of the cone surface and the elements themselves are left in full lines. The true lengths of lines 1 to 7 inclusive are obtainable directly from the conical surface by the use of the semicircles as

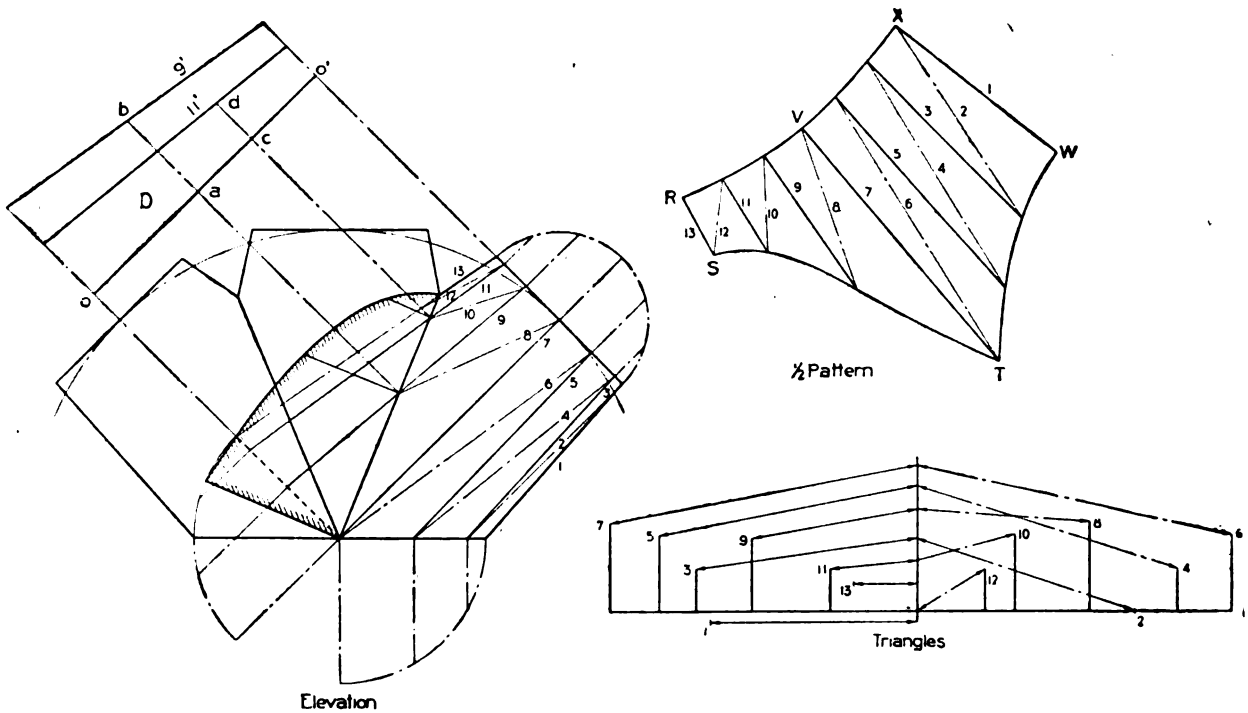

Fig. 236. Elevation, Diagram of Triangles and Pattern

shown, the diagram of triangles being a usual one. When one comes to the rest of the surface of the prong at the right side, the actual distance of the ends of the lines 8, 9, 10, 11, 12 and 13 from the imaginary plane passed through the center of all of the prongs (and thus dividing the circular opening at bottom and top into the semicircle as shown) is obtainable from the semicircles. The distances of other points on this conical surface from this same plane are derived by remembering that they lie in definite elements of the surface of the right cone.

Other elements of the right prong surface are continued to a dotted line representing the base of the cone, and at that point a quarter circle is drawn in order to

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learn the distance of the ends of the elements from the plane already mentioned. To the left of the cone has been drawn the line 0 0′, parallel to the axis of the right cone. From the semicircles at the opposite end of elements 9 and 11 distances have been laid off perpendicularly to the line 0 0′, and the resultant inclined lines 9′ and 11′ at D show the distance of any point in either of these lines from the lines 0 0′, or, in other words, the distance from the plane passed through the center of the right cone.

The application of this simple arrangement is as follows: To get the actual length of the line 8, the horizontal distance is laid off as usual in the diagram of triangles. The distance of one end of the line 8 from the imaginary plane is obtainable from the upper semicircle. The distance of the other extremity of the line 8 from that same plane is obtainable from the diagram D. As this extremity of 8 lies on the element 9, the distance of the extremity of line 8 from the plane is equal to the distance *a b* of the diagram D. Similarly, the distances from the plane mentioned for determining the actual length of the line 9 are obtainable in one case from the small semicircle and in the other case by the distance *a b*. Similarly, the line 10 has one extremity in the element 11, and this distance is equal to *c d* of diagram D.

The one half pattern shown is obtained in the usual way by taking the equal distances from the semicircles and also the actual length of the lines as shown in the diagram of triangles, alternating with full and dotted lines. The entire half pattern R S T W X is a half pattern for each of the outer prongs. The part of the pattern R S T V is a quarter pattern of the central prong.

PATTERNS FOR INTERSECTING PIPES

The following is the method of laying out the patterns for a round smoke pipe that joins an upright pipe having flat sides and round ends. The round pipe inclines to the vertical pipe at about 45 degrees, both vertically and horizontally.

In the accompanying illustration, Fig. 237, A B in plan represents the oblong pipe, while C D shows the round pipe intersecting the oblong pipe at an angle of 45 degrees. A^1 B^1 shows the elevation of the oblong pipe intersected by the round pipe C^1 D^1, also at an angle of 45 degrees. The line of intersection in the elevation has been omitted, as it is not required in the development of the pattern. If the intersections were required for the purpose of making a finished drawing this could be done by dropping lines from the intersections in plan into

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the elevation, and intersecting same by lines drawn from the intersections in the profile b'' from similar numbers, parallel to the lines of the pipe.

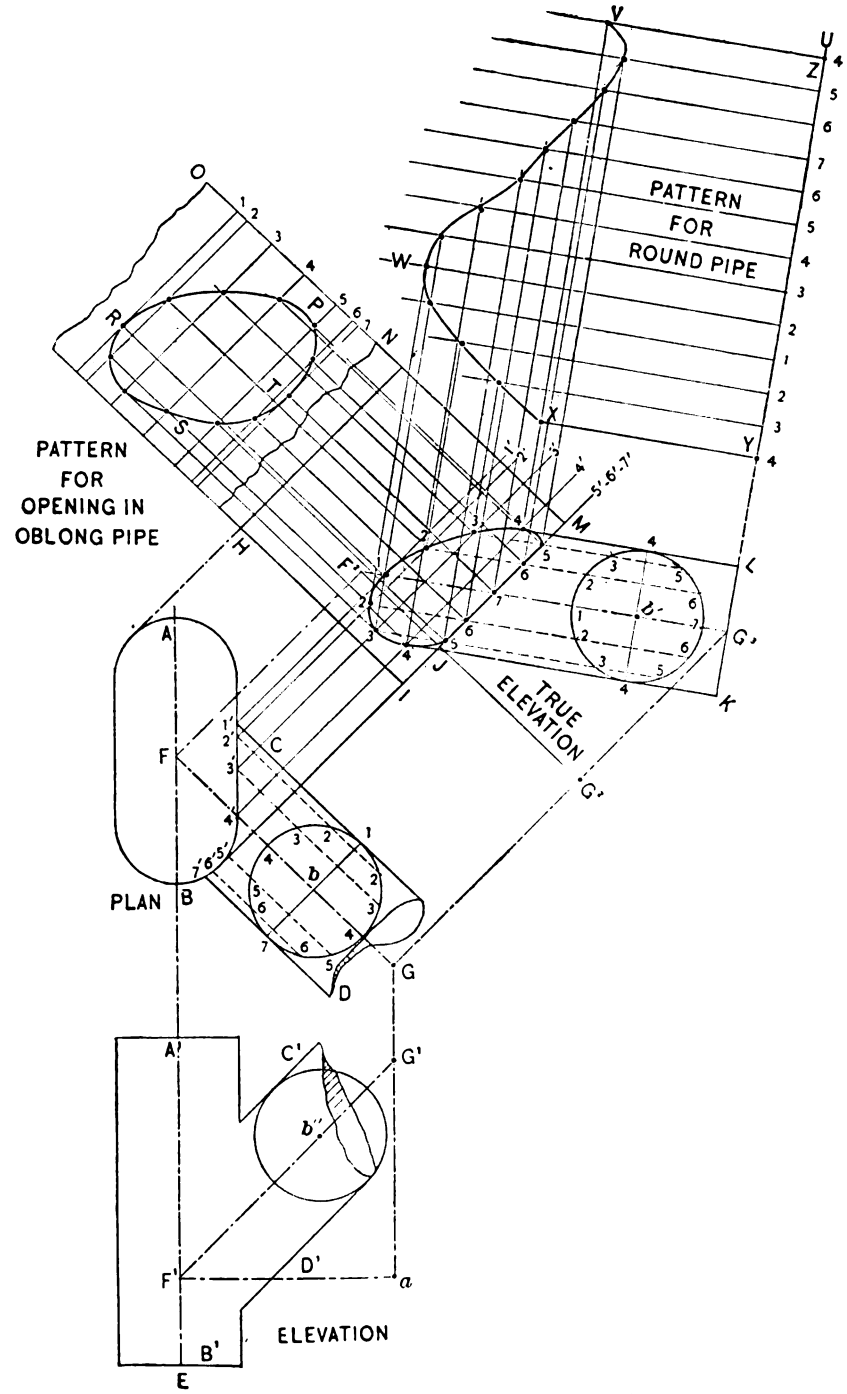

Fig. 237. Plan Elevation, True Elevation and Patterns

The first step necessary in the development of the patterns is to obtain a true elevation, for which proceed as follows: Draw a center line through the elevation

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and plan of the oblong pipe, as shown by A E. In similar manner draw a center line through the round pipe C D in plan, as shown by F G, intersecting the line A E at F. Also draw a line through the center of the round pipe in elevation, as shown by G^1 F^1, intersecting the center line A E at F^1. At pleasure establish any point on the center line F G in plan, as G. From G drop a perpendicular line intersecting the center line F^1 G^1 in elevation at G^1, extending the line G G^1 until it intersects the line drawn from the point F^1 at right angles to A^1 E at *a*. Then will these points form the basis of measurements for obtaining the true elevation.

Now parallel to F G in plan draw the line F^2 G^2, equal in length to F G. At right angles to F^2 G^2 draw the line G^2 G^3, equal to *a* G^1 in elevation. Draw a line from G^3 to F^2, which will represent the true length of the center line of the round pipe on F G in plan. At right angles to F^2 G^3 draw the line L K, equal to the diameter of the round pipe, and describe the circle *b'*, which divide into equal spaces, as shown. In similar manner describe the circle *b* in plan view, which divide into the same number of spaces, as shown from 1 to 7 to 1. Parallel to the lines of the pipe draw lines intersecting the oblong pipe at points 1' to 7'. Then at right angles to F G and from points 1' to 7' draw lines indefinitely, as shown, which intersect with lines drawn parallel to F^2 G^3 from similar numbered intersections in the circle *b'*, as shown by points in the miter line 1 to 7 to 1. Trace a line through points thus obtained, which will give the true points of intersections between the round and oblong pipes at an angle of 45 degrees, both vertically and horizontally.

As confusion is apt to arise in numbering the points in circles *b* and *b'* an explanation may not be out of place. Assume that 1 7 in plan of the circle *b* is a pivot, and the circle is turned so that one point 4 comes above and the other point 4 below, then for this reason should the points 4 and 4 in circle *b'* come below and above respectively, as shown.

From the extreme point of the oblong in plan, as A, erect the line to the true elevation, as shown. Then will H I J K L M N be the true elevation of the round and oblong pipes. For the pattern for the opening to be cut into the oblong pipe extend the line M N, as shown by M O, upon which place the stretchout of the intersections on the oblong pipe in plan 1' to 7', as shown by the small figures 1 to 7 on N O. From these small figures and at right angles to O N draw lines, as shown, which intersect by lines drawn from similar numbered intersections in the miter line M F^2 J at right angles to M I. Trace a line through the points thus obtained, then will P R S T be the pattern shape for the opening in the oblong pipe.

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For the pattern for the round pipe draw any line at right angles to J K, as Y U, upon which place the stretchout of the circle *b'*, as shown by 4 to 1 to 4 to 7 to 4 on Y U, thus bringing the seam on the line 4 L in true elevation. At right angles to Y U and from the small figures draw lines indefinitely, which intersect by lines drawn at right angles to M L in true elevation from similar numbers in the miter line M F^2 J. Trace a line through these points of intersections thus obtained in pattern, as shown by V W X. Then will V W X Y Z be the pattern for the round pipe.

TAPERING ELBOW IN SQUARE PIPE

This is an exemplification of how to lay out an elbow, tapering from 10 inches square to 4 inches square. In Fig. 238, let 1 2 3 4 5 6 be the side elevation of the elbow, 1 2 3 forming a right angle. Let 1′ 6′ 6″ 1″ be the section in plan on the line 1 6 in elevation, and A B C D the section on 3 4. Through this section draw the center line E F. Draw J H, the center line in plan.

As the elbow tapers it will be necessary to obtain the true widths at the points 2 and 5 in elevation, as follows: Upon the line H J in plan lay off the stretchout of 1 2 3 in elevation, as shown by 1°, 2° and 3° in plan. At right angles to H J, and through these small figures, draw 1 1, 2 2 and 3 3, making 1 1° equal to half 1′ 1″ in plan, and 3 3° to A E or E B in section. On both sides, from the points 3 draw lines to 1, intersecting 2 2. Then 1 2 3 3 2 1 will be the pattern for the top of the elbow, shown by 1 2 3 in elevation; 2 2 in the pattern is the true width in plan on the point 2 in-elevation.

In similar manner take the stretchout of 6 5 4 in elevation and place it on the line H J in plan, as shown by 6°, 5° and 4°. Proceed as before, obtaining 4 5 6 6 5 4, the pattern for the bottom of the elbow shown by 4 5 6 in elevation; 5 5 in pattern is the true width on 5 in elevation.

To draw the plan of the elbow proceed as follows: Parallel to H J in plan, and from points 2 and 2 in pattern, draw lines intersecting 1′ 1″ at 2′ 2″. This gives the width in plan of point 2 of elevation. At right angles to 2 3 in elevation, and from points 3, 4 and 5, drop lines into the plan indefinitely, which intersect lines drawn parallel to H J from points having similar numbers on the two patterns, as shown by intersections 3′ 4′, 3″ 4″, 5′ and 5″ in the plan. Draw lines from 6′ to 5′ to 2′ to 3′ 4′ to 5′; also from 6″ to 5″ to 2″ to 3″ 4″ to 5″, which will be the plan of the elbow.

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Before obtaining the patterns for the sides of the lower and upper arms it will be necessary to construct three triangles, for which proceed as follows: Draw dotted lines in elevation from 3 to 5 and from 5 to 1. These are represented in plan by 3′ 5′ and 5′ 1′. At right angles to 2 1 in elevation, and from points 2, 5 and 1, draw lines to the left indefinitely, as shown. Now take the distance of 5 1′ in plan and place it on 1 K, as shown by 5^x 1^x. From 5^x erect a line intersecting 5 L

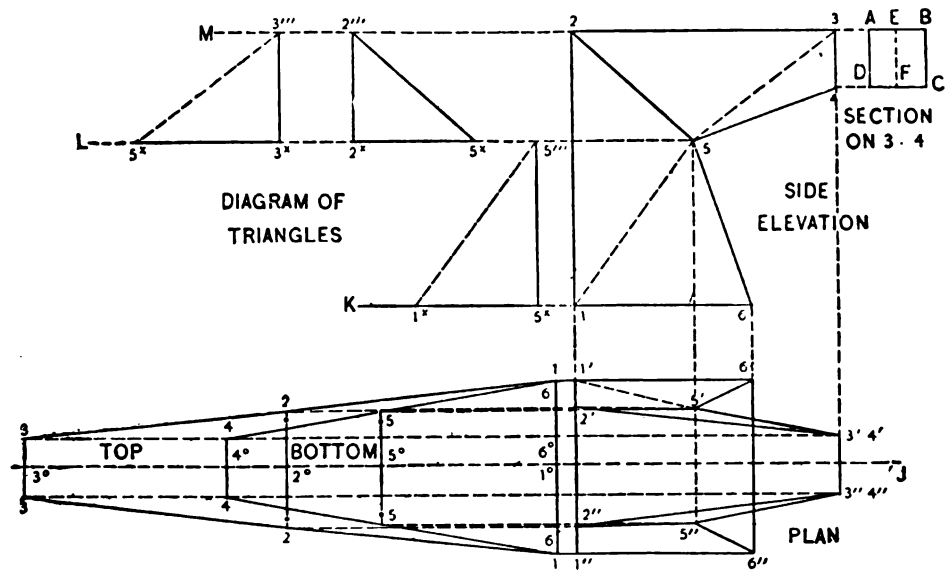

Fig. 238. Plan, Elevation and Patterns for Top and Bottom

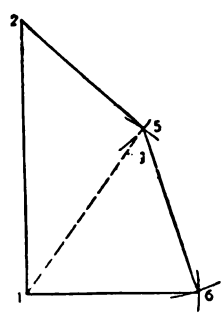

Fig. 239. Pattern for Lower Side

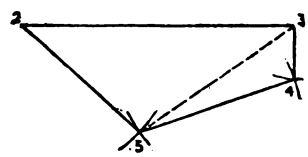

Fig. 240. Pattern for Upper Side

at 5‴. Draw 5‴ 1^x, which is the true distance on 5 1 in elevation. In similar manner take the distances in plan 2′ 5′ and 5′ 3′ and place them on 5 L, as shown by 2^x 5^x and 5^x 3^x. From 3^x and 2^x erect lines intersecting 2 M at 3‴ and 2‴. Then will 2‴ 5^x and 3‴ 5^x be the actual distances on the finished elbow when measured on the lines 2 5 and 3 5 in elevation.

For the pattern for 1 2 5 6 draw any line, as 1 2 in Fig. 239, equal to 1 2 in the patterns for top in Fig. 238. Then with 1^x 5‴ in the diagram of triangles

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as radius, and 1 in Fig. 239 as center, describe the arc 5, which intersect with an arc struck from 2 as center, with a radius equal to 2‴ 5ˣ in the diagram of triangles in Fig. 238. With 5 6 in the pattern for bottom as radius, and with 5 in Fig. 239 as center, describe the arc 6. With 1 as center, and with 1 6 in elevation in Fig. 238 as radius, intersect the arc 6 in Fig. 239, as shown. Trace a line through points thus obtained. Then will 1 2 5 6 be the desired pattern.

For the pattern for the upper side of the elbow draw 2 3 in Fig. 240 equal to 2 3 in the pattern for top in Fig. 238. Then with 2‴ 5ˣ in the diagram of triangles as radius, and with 2 in Fig. 240 as center, describe the arc 5, which intersect by an arc struck from 3 as center, with a radius equal to 3‴ 5ˣ in the diagram

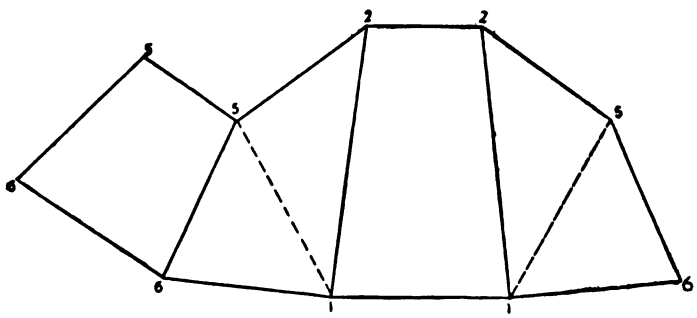

Fig. 241. Pattern for Lower Arm in One Piece

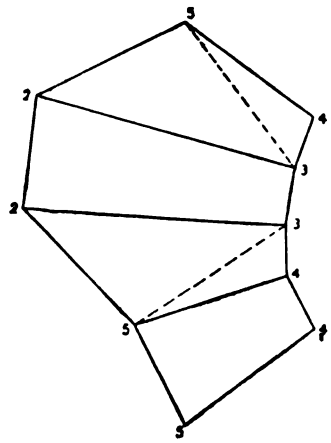

Fig. 242. Pattern for Upper Arm in One Piece

of triangles in Fig. 238. Now using 3 4 in elevation as radius, and 3 in Fig. 240 as center, describe the arc 4, which intersect by an arc struck from 5 as center, with a radius equal to 5 4 in the pattern for bottom in Fig. 238. A line traced through these points, as shown by 2 3 4 5, will be the desired pattern.

If it is desired to make the lower and upper arms each complete in one pattern, this can be done as shown in Figs. 241 and 242. In Fig. 241, 1 2 2 1 is a tracing of the top pattern 1 2 2 1 in Fig. 238, while 1 2 5 6 on either side in Fig. 241 is a tracing of 1 2 5 6 in Fig. 239, and 5 6 6 5 in Fig. 241 a tracing of 5 6 6 5 in the pattern for bottom in Fig. 238. Fig. 242 is a similar combination of the patterns of the sides for the upper arm of the elbow.

PATTERNS FOR INTERSECTING TAPERING ELBOWS

This problem is to find the patterns for two similar, pieced tapering elbows that intersect. The elbow has three openings as shown in Fig. 243. The two

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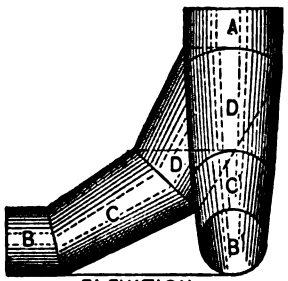
arms of the elbow are symmetrical, so it will be necessary to construct the elevation of but one arm, in which the true taper, miter lines and true sections are obtained.



ELEVATION
Fig. 243. Sketch of the Problem

From A, in Fig. 244, with radius equal to the curve made by the center line of one branch, describe the arc D E. As the elbow has four pieces, divide D E into three equal parts by *a* and *b*. Bisect D *a*, obtaining the joint *c*. Starting from *c*, set the dividers equal to D *a* and step off to the points *d* and *e*. From A draw lines through D, *c*, *d*, *e* and E. Perpendicular to A D draw D *h*. From *d* and *e*, on the miter lines M N and G H, lay off distances equal to *c h*, locating points *i* and *f*. Draw *h i*, *i f* and *f* E, the center lines of the elbow pieces. Describe the half sections U and P of the large and small ends, from D and E as centers. From I and B draw lines parallel to D *h*, intersecting J K. In similar manner, from C and F draw lines parallel to E *f*, intersecting H G. To obtain a proportionate taper between J K and G H, take half of G H and place it on J K, from *h* to *j*. Bisect *j* K, obtaining *n*. Take the distance *h n* and place it on M N, from *i* to N and *i* to M. Draw J M, M G, K N and N H. Then will I F C B be the desired elevation.

To obtain the true sections on J K, M N and G H, divide U into equal parts, as shown by 1 to 5. From these draw lines parallel to D *h*, intersecting J K from 1‴ to 5‴. From these points, perpendicular to J K, draw the lines 2‴ 2, 3‴ 3 and 4‴ 4, equal to the hights of 2, 3 and 4 in U. Draw the semiellipse T, the true half section on J K. In similar manner obtain half section R. For the half section on M N, draw from *i*, *i o*, perpendicular to *h i*. Then perpendicular to M N draw *i* 3, equal to *i o*. Through M, 3 and N draw the semiellipse S. Divide this into four equal parts, and from these points drop lines intersecting M N at 1″ to 5″.

It is now necessary to obtain a plan of the elbow, showing the intersection between the two arms and the horizontal projections of the miter lines. To avoid confusion of lines, a tracing of the elbow is taken and placed in Fig. 245. Draw the horizontal line O P. From D erect D 5°. From 5° describe the circle 1 3 5 3, representing the section on I B. Divide U into the same number of parts as contained in U in Fig. 244, as shown by similar figures.

Take a tracing of the half section S, in Fig. 244, and place it as shown by S in plan in Fig. 245, the center *i* and the points 1 and 5 being on O P. Parallel to O P, from the small figures in S, draw lines, partly shown, intersecting lines drawn at right angles to O P from similarly numbered intersections on M N.

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Trace a line through points thus obtained; then will S^1 be the horizontal projection of section on M N.

From F, G and H erect lines intersecting O P at F^1, G^1 and H^1. Take the distance of E F and place it as shown from F^1 to E^1 and F^1 to E^2. From E^1 and E^2 draw horizontal lines, intersecting the line erected from *f* in elevation at *f'* and *f''* in plan. Trace an ellipse through *f'*, G^1, *f'''*, H^1 and draw *f''* 3 3 and *f'* 3 3. Then will E^2 3 5 3 E^1 be the plan of one arm of the elbow.

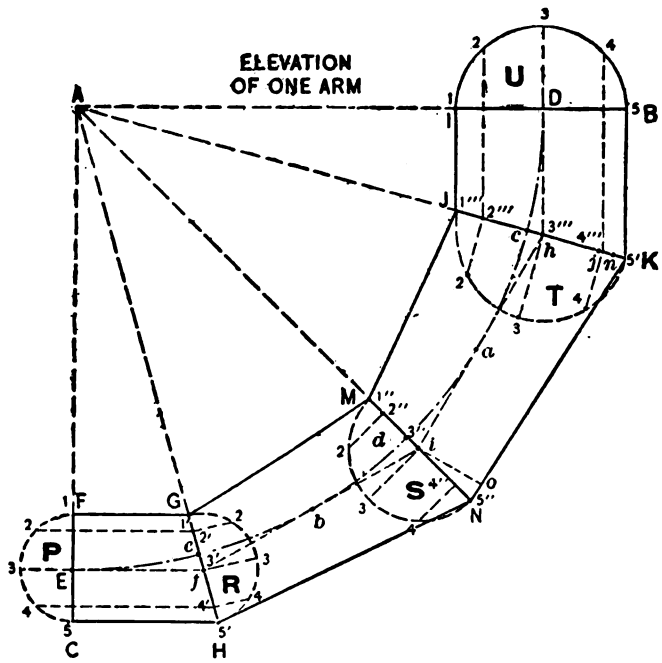

Fig. 244. Elevation of One Arm and Sections

Through the point 5° in plan, at an angle of 45 degrees, half the angle at which the arms meet in plan, draw the projection of the line of joint R T.

The patterns for I B K J and F G H C are obtained by the usual method employed for finding elbow patterns in round pipe. The half patterns are developed in Fig. 245 and are shown by U^1 V X W and Y G^1 H^1 Z.

From the various intersections on J K and M N draw solid lines from 2″ to 2‴, 3″ to 3‴ and 4″ to 4‴, and dotted lines from 2″ to 1‴, 3″ to 2‴, 4″ to 3‴ and 5″ to 4‴. In similar manner connect the same numbers in U and S^1. The joint line, R T, in plan cuts 5 5 at 5°, 5 4 at *b*, 4 4 at 4°, 4 3 at *a* and 3 3 at 3°, and the section U at 2 and 4. From these various points of intersection drop lines intersecting similarly numbered solid and dotted lines in elevation, as shown respectively by 5°, *b*, 4°, *a*, 3°, 2° 2°, 4° and 4°. Trace a line

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through points thus obtained, which will be the line of joint in elevation. This has been shaded in Fig. 245 to clearly show the plane of the miter line.

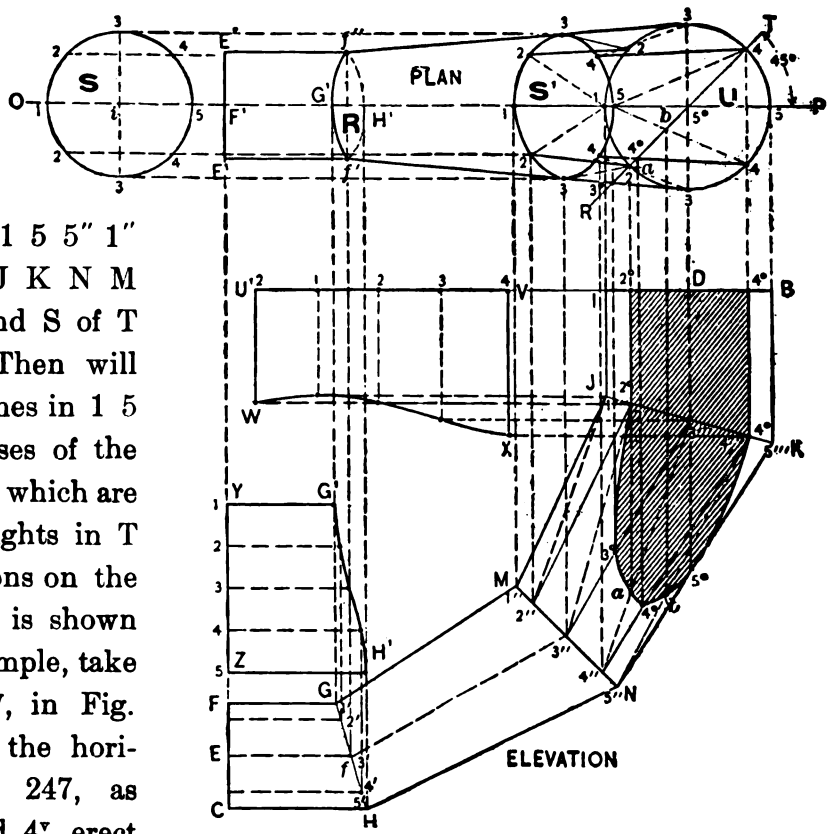

Fig. 245. Plan and Elevation and Patterns for End Pieces

The next step is to obtain measurements for the diagram of sections on the various solid and dotted lines. In Fig. 246, 1 5 5″ 1″ is a reproduction of J K N M in Fig. 245, and T and S of T and S in Fig. 244. Then will the solid and dotted lines in 1 5 5″ 1″ represent the bases of the sections the altitudes of which are equal to the various hights in T and S. For the sections on the solid lines proceed as is shown in Fig. 247. For example, take the distance of 4′ 4ᵛ, in Fig. 246, and place it on the horizontal line in Fig. 247, as shown. From 4′ and 4ᵛ erect lines 4′ 4 and 4ᵛ 4″, equal to 4′ 4 in T and 4ᵛ 4″ in S, in Fig. 246. Draw 4 4″ in Fig. 247, which represents the true length on 4′ 4ᵛ in Fig. 246. In this manner the other sections on the solid lines are obtained. The same principle is used in obtaining the sections on the dotted lines, as shown in Fig. 248.

For the pattern, draw 5 5″, in Fig. 249, equal to 5 5″ in Fig. 246. Then, by the usual rules of triangulation, develop the half pattern, as shown by 5 1 1″ 5″ in Fig. 249. Opposite it trace the other half, shown by 5 1ᵛ 1ˣ 5″. The full pattern is thus obtained, on which must be located the miter line. Take the various distances on the solid lines in Fig. 246, as 3′ to 3° and 4′ to 4°, and place them on the horizontal line in Fig. 247, as shown from 3′ to 3° and 4′ to 4°. From 3° and 4° erect lines intersecting 3 3″ and 4 4″ at 3ˣ and 4ˣ respectively. Take the distances 3 to 3ˣ and 4 to 4ˣ and place them on similar numbered solid lines in the pattern in Fig. 249, as shown from 3 to 3° and 4 to 4°. Now take the distances in Fig. 246, on the dotted lines, from 3′ to *a* and

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from 4′ to *b*, and determine their true lengths in Fig. 248. Take these true distances, placing them on similarly numbered dotted lines in pattern, thus locating *a* and *b* in Fig. 249. Take the distance from 5 to 5° in Fig. 246 and place it from 5 to 5° in Fig. 249.

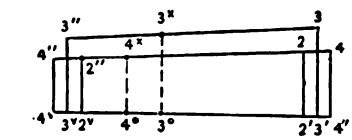

Fig. 247. Sections on Solid Lines

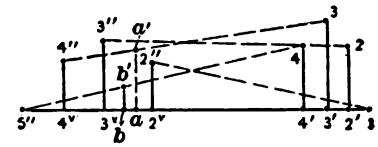

Fig. 248. Sections on Dotted Lines

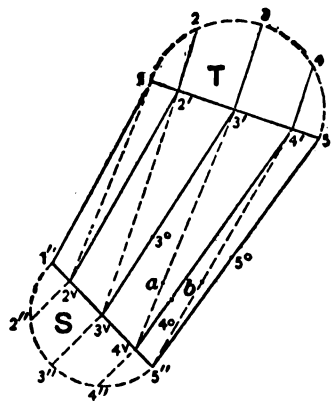

Fig. 246. Diagram for Obtaining Measurements for Sections

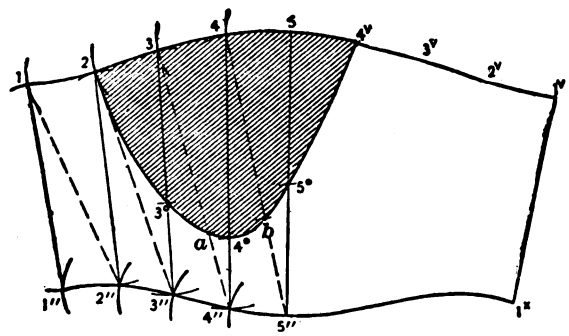

Fig. 249. The Pattern for J K N M in Fig. 245

As the line of joint R T in plan, in Fig. 245, passes through point 2 and 4, start from 2 in Fig. 249 and trace a line through 2, 3°, *a*, 4°, *b*, 5°, 4ᵛ. Then will 1 2 4° 4ᵛ 1ᵛ 1ˣ 1″ be the full pattern for J K N M in Fig. 245 for each arm. In the same manner obtain the pattern by triangulation for the piece M N H G, using the sections S and R in Fig. 244. Laps must be allowed for seaming or riveting.

PATTERNS FOR SHIP VENTILATING COWL

An interesting article on patterns for a ship ventilating cowl was written for *Metal Worker*, and is as follows:

What is termed a standard cowl is explained in connection with Fig. 250. Start by erecting a line perpendicular to the base line from point A, extending it indefinitely. The diameter of the base, assuming it to be 14 in., is marked off to the right of this line, establishing point B. The radius of the throat is next determined by taking one-fourth the diameter of the base, or 3½ in., which is marked off on the base line to the right from point B to point C. From C erect a line with an inclination to the right of 82 degrees from the base line. With one leg of the dividers at C and with radius 3½ in., or B C, draw the throat line until it intersects the inclined line at point D. The mouth of the cowl is laid off

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on the inclined line from point D, and is found by taking twice the diameter of the base, which gives 28 in. With this distance from point D establish point E. Draw the radius of the back, which is taken as one and one-half times the diameter of the base, in this case 21 in. With this radius and one leg of the dividers at point E, the other should be so located that when the arc defining the back is drawn the vertical line, erected from the base line at point A, will be tangent to it, completing the outline of the cowl. This method, in the form of a formula, is assuming B to represent base; T, throat; M, mouth, and R, radius of back, would read: B = 14 in.; T = ¼ B, or 3½ in.; M = 2 B, or 28 in.; R = 1½ B, or 21 in.

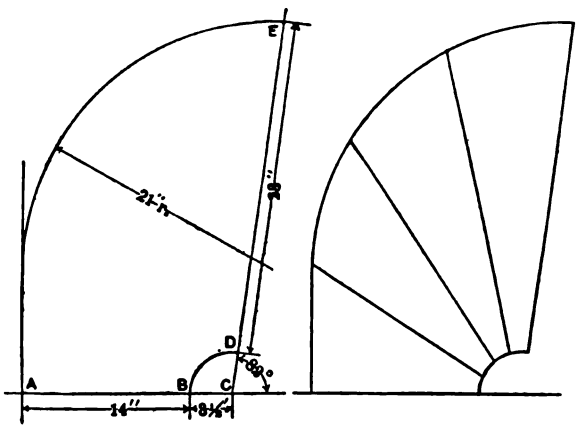

Fig. 250. Elevation in Outline Fig. 251. Division of Cowl

The back and throat lines are now divided into four equal parts and these points connected by lines, as in Fig. 251, thus dividing the surface into four sections, each section of which is developed by triangulation. The development of one section will serve to show the method employed in all.

To avoid confusion of lines transfer the bottom section, as in Fig. 252, where A G and 1 7 represent the section. Bisect A G and 1 7, and with these points as centers draw a semicircle on each side, which will represent a half plan of each end of the section. Divide these semicircles into a convenient number of equal parts, in this case six. Project these points to the elevation by lines in the semicircle A G. Letter these lines A, B, C, etc. To avoid confusion in the semicircle 1 7, number the lines 1, 2, 3, etc. Divide the elevation into triangles by connecting 1 and B, B and 2, 2 and C, C and 3, 3 and D, and so on, until all the points have been connected. Beginning with the line 1 A, letter and number each line, as B′ 2′, C′ 3′, D′ 4′, etc. At any convenient place draw a straight line and erect a line perpendicular to it. Take the length of the line B′ and transfer it to this line,

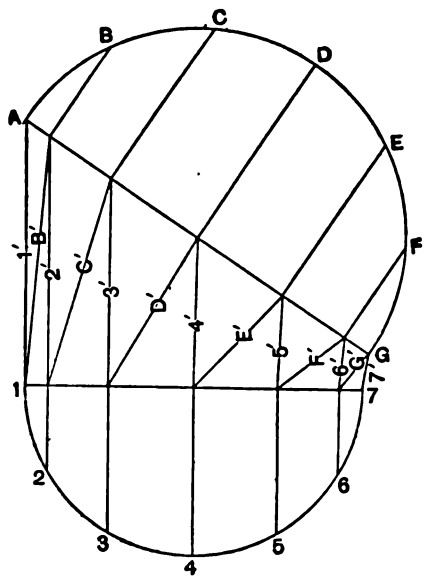

Fig. 252. Development of One Section

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as shown, and likewise take the line B in the plan and transfer it to the base line, as in Fig. 253. Connecting these two points gives a right angled triangle, and the hypotenuse, or line B^2, is the true length of B′ in elevation. Erect another perpendicular line and transfer the length of the line marked 2′ to it, as shown. Take the length of the line 2 in plan of small end and transfer it to line B in plan of large end. Take the difference in length of these two lines and mark it off on the base line from the intersection of the perpendicular line as at 2 B.

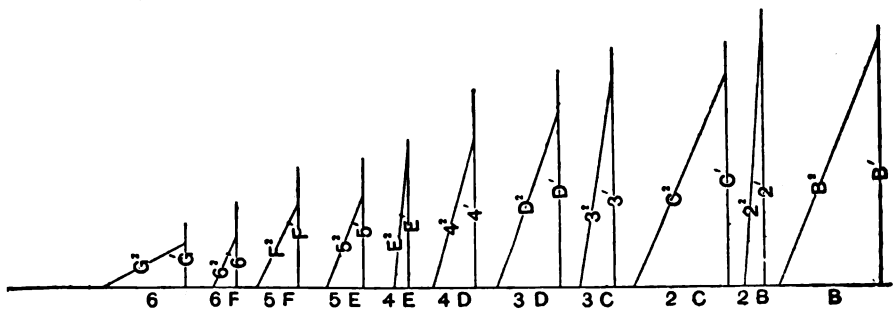

Fig. 253. Determining Lengths of Lines in the Elevation

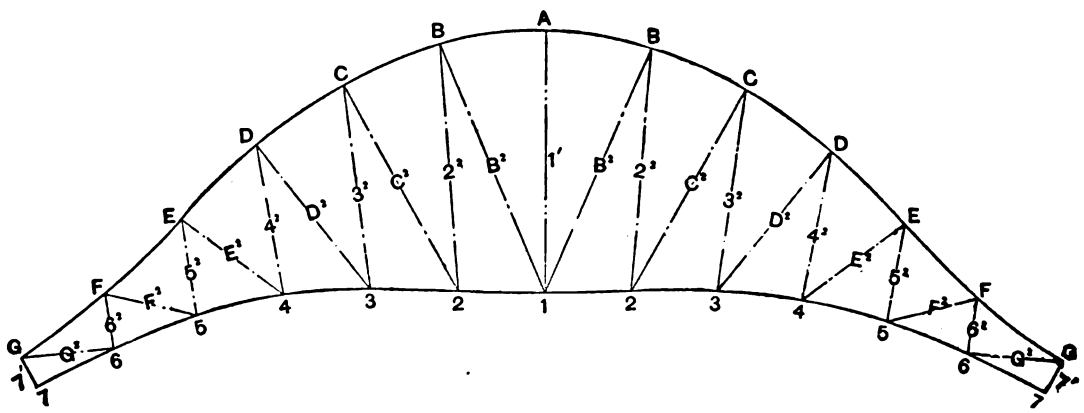

Fig. 254. Development of the Pattern

Connect these two points, giving another right angled triangle, of which the hypotenuse, or line 2^2, is the true length of line 2′ in elevation. This process is now repeated by erecting another perpendicular and transferring the length of line C′ to it, and taking the difference in length of lines 2 and C and transferring it to the base line as before. The points being connected, another right angled triangle is obtained, the hypotenuse, or C^2, being the true length of C′ in elevation.

This process is repeated until all the true lengths of the different triangles have been found, after which all is ready to proceed with the development of the pattern. Accordingly, in any convenient place, draw a line of indefinite length. On this line lay off the distance from 1 to A in elevation, this being the true length of the

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center line. Next, with the point A as center and with a radius equal to one of the spacings in the large semicircle, or half plan of top, as A to B, describe an arc of indefinite length. Then, with a radius equal to the length of the hypotenuse of the triangle that represents the true length of the line B′, as at B^2, and with 1 as center, intersect the arc, as at B. Then, with 1 as center and radius equal to 1 2 in plan, describe another arc and intersect, as at 2, with a radius equal to the hypotenuse of the next triangle, using B as center. This process is repeated until the true lengths of all the triangles have been used, finishing with the line G 7 of elevation, which is shown in its true length in that place. A line traced through these points gives the development of the required pattern, minus the necessary laps.

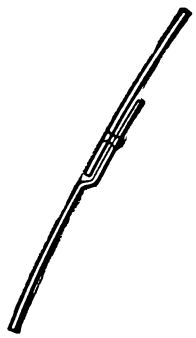

Fig. 255. Method of Making the Seams

This line is termed the rivet line, the necessary holes being laid off on it. Considerable care is necessary in the spacing of these holes in the different patterns, also in transferring the different sections, due allowance being made for the thickness of material. Consequently the top of one section will be smaller than the bottom of the next, so as to allow them to be assembled without too much stretching.

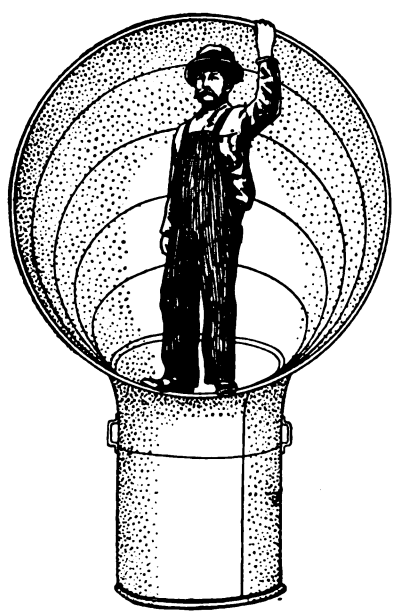

Fig. 256. Front View of Large Cowl

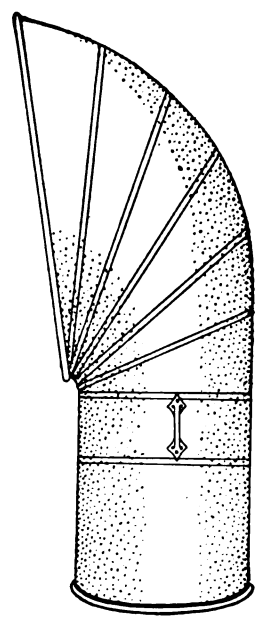

Fig. 257. Side View of Large Cowl

The cowl is raised with a raising hammer until the center line at the back forms a true arc, gradually diminishing each side of the center. The rivets are also countersunk and make the seams as shown in Fig. 255. The seam is soldered on the outside and the surplus solder scraped off, which leaves the cowl perfectly smooth outside, while the three seams inside have a tendency to reinforce and stiffen the cowl. It is also further reinforced by finishing around the mouth with a suitable sized bead iron, the rivets being countersunk to conform to the rest of the cowl.

The material used is galvanized steel which was found to be much superior in regard to lasting qualities to planished iron or black steel. The two illustrations,

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Figs. 256 and 257, show an exceptionally large cowl, the diameter of the base of which is 37 in. Consequently the mouth is 74 in. Owing to having no sheets larger than 36×96 in., the rule of four pieces was departed from, as will be noticed from an inspection of the pictures.

PATTERNS FOR AN IRREGULAR T JOINT

To develop the patterns for an irregular T joint, in which the branch pipe is to be 7 in. and is to intersect the main 16-in. pipe to one side of its center, as

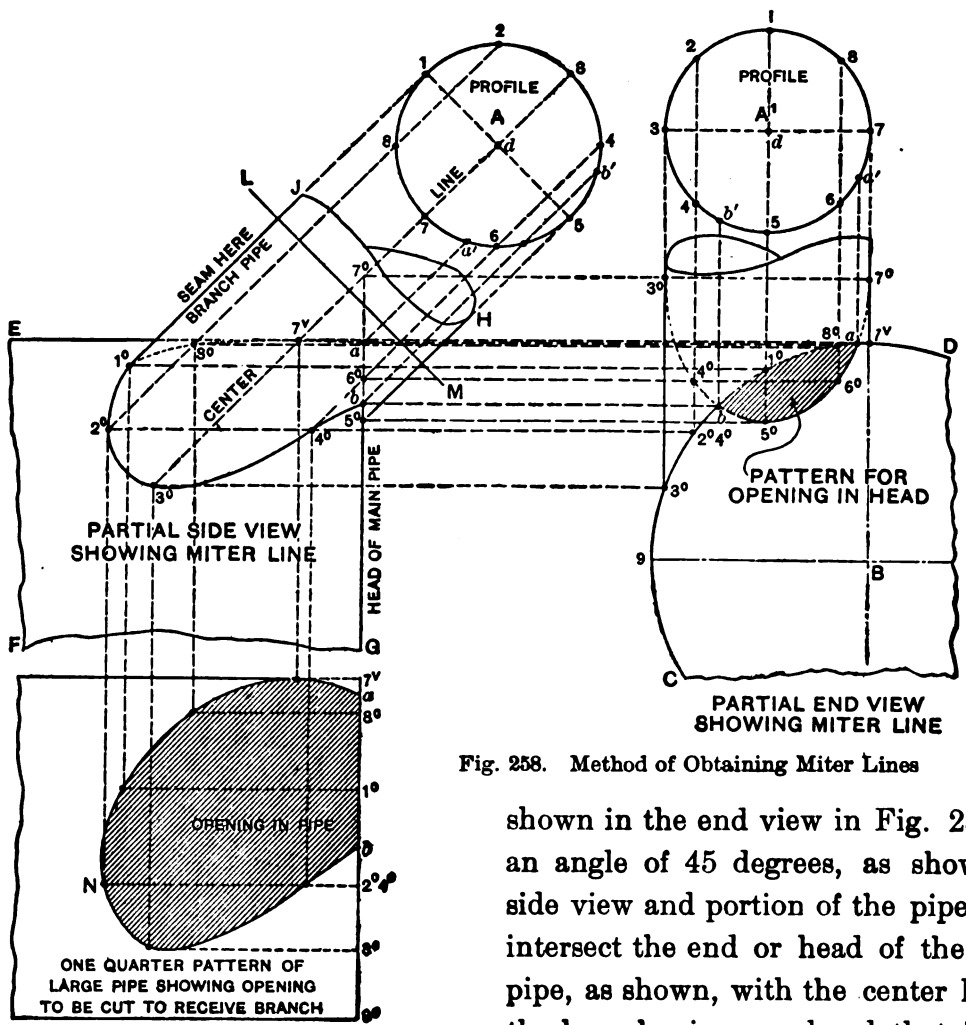

Fig. 258. Method of Obtaining Miter Lines

shown in the end view in Fig. 258, at an angle of 45 degrees, as shown in side view and portion of the pipe is to intersect the end or head of the large pipe, as shown, with the center line of the branch pipe so placed that if will not come in contact with the head of the main pipe; proceed as follows:

All of the above conditions have been observed in Fig. 258 except that the profiles of the pipes are somewhat larger than called for, which allows the principles

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to be clearly shown. The locating of the miter lines is the most difficult part of the problem, for after the miter lines have been found the development of the patterns are simple. With the proper size radius and any point as B as center draw a partial end view of the large pipe, as shown by C D. Through B draw the vertical line B 7 and the horizontal line B 9. As the branch pipe is to be placed to one side of the center line then draw at pleasure the horizontal line 7 3, equal to the diameter of the branch, which bisect and obtain *d*. With *d* as center and *d* 3 as radius describe the circle A^1. Divide this profile into equal parts, as shown from 1 to 8, from which points vertical lines are drawn indefinitely, intersecting the curve C D of the main pipe at 1° to 8°, as shown.

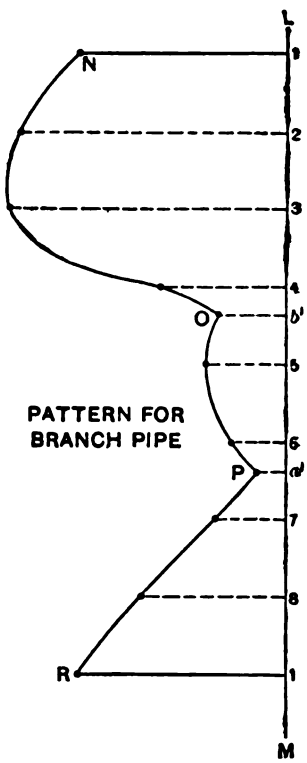

Fig. 259. The Pattern

From the end view project the partial side view of the main pipe, as shown by E *a* G F. As the center line of the branch pipe should not come in contact with the head line *a* G, then let 7° or any other point be on the center line, and through this point at an angle of 45 degrees draw the line 3°, 3. Establish on this line any point, as *d*, which use as a center, and describe the profile A similar in size to the profile A^1. Through *d* draw the diameter 1 5 perpendicular to the center line 3° 3, and divide A in the same number of spaces as A^1, and if point 1 is at the top in the profile A^1 it will be placed at the top in the profile A, as shown. Through these points, 1 to 8 in A, draw lines parallel to 3 3° indefinitely, as shown.

The first step in obtaining the miter lines is to find out how much of the branch pipe will intersect the head of the main pipe and is done as follows: Extend the head line G *a* of the main pipe until it meets the center line at 7°. Now, where the lines 3 7, 4 6 and 5 drawn from the profile A, cut the head line G 7°, draw horizontal lines in the end view until they intersect similar lines drawn vertically from similar numbers in the profile A^1, as shown by intersections 3°, 4°, 5°, 6° and 7°, thus obtained. Trace the elliptical figure through these points, as shown, and where this elliptical outline cuts the profile of the main pipe at *a* and *b*, are the desired points. From *a* and *b* draw vertical lines to the profile A^1, intersecting same at *a'* to *b'*. The distance from *a'* to *b'* shows the amount that the branch will intersect the head of the main pipe and the shaded portion *b* 5° 6° *a* 8° 1° *b* shows the pattern for the opening to be cut in the head of the main pipe.

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Now, take the distances from 4 to b' and 6 to a' in the profile A^1, and place them from 4 to b' between 4 and 5, and 6 to a' between 6 and 7 in the profile A, and from these points a' and b' parallel to the line 3 3°, draw lines until they intersect the head line G 7° at a and b. If these points are in their true position they will be intersected by horizontal lines drawn from a and b in the end view.

To find the miter line of the rest of the branch pipe a' 1 b' with the main pipe, extend horizontal lines from the various intersections on the curve C D in the end view until they intersect similar numbered lines drawn from the profile A in the side view, as shown by the points of intersections a, 7°, 8°, 1°, 2°, 3°, 4° and b. If desired a curved line can be traced, giving the miter line in both views.

For the pattern for the opening to be cut in the main pipe, take the girth of all the spaces contained in the curve C D in end view from 9 to 7°, as shown by similar letters and figures placed on the line G 9 below the side view. From these small figures, at right angles to G 9, draw lines, which intersect by lines drawn parallel to G 9, from similar numbered intersections in the miter line in the side view. Trace a line through points thus obtained, as shown by a N b, then will the shaded portion be the desired opening.

The pattern for the branch pipe is shown in Fig. 259, and is obtained as follows: Take the girth of the profile A in Fig. 258 each and every space, and place it on any vertical line L M in Fig. 259, as shown by similar letters and figures. Through these figures at right angles to L M draw lines indefinitely, as shown. At pleasure, at right angles to 3 3° in Fig. 258 draw any line as L M. Now, measuring from this line, L M, take the various distances to points 1° to 5° to a to 1°, and place them on similar lines in Fig. 259, measuring in each instance from the line L M. A line traced through points thus obtained, as shown by N O P R, will be the miter cut for the branch pipe, with the seam at 1 as called for in Fig. 258. The miter cut N O and P R in Fig. 259 joins the curved part of the main pipe, while the miter cut from O to P joins the opening in the head from b to 5° to 6° to a in the end view in Fig. 258.

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